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Book of abstracts

LUND UNIVERSITY

COGAIN Communication by Gaze Interaction

Eye Movement Researchers Association

Contents

Keynote speakers

Room: Stora salen

Carlos Morimoto

University of São Paulo, Brazil

Carlos Hitoshi Morimoto has a B.Sc. and M.Sc. in Electronic Engineering from the University of São Paulo, and a Ph.D. in Computer Science from the University of Maryland at College Park. After completing his Ph.D. he joined the IBM Almaden Research Center to work in the BlueEyes project in 1997, where he started working with eye gaze tracking. In 1999 he left IBM to become a faculty member of the Department of Computer Sciences of the University of São Paulo, but continued collaborating with IBM in further developing eye tracking technology and gaze interactive applications. He has served as program co-chair of the ACM Eye Tracking Research & Applications Symposium (ETRA) in 2008, and as general co-chair of ETRA in 2010 and 2012.

His current projects are aimed at monitoring and understanding human activity to improve human-computer interactions using real-time computer vision techniques, focusing on detection and tracking of people and their body, face, and eye movements. One of the main focus of his research has been on the development of low cost eye gaze trackers that are calibration free and robust to head movements.

Abstract

The Geometry of Eye Gaze Tracking

Video based eye gaze tracking has become the dominant technique over EEG and magnetic coil based systems, because it offers better accuracy than EEG, and it is easier to setup and use than coils. Despite many recent advancements, video based gaze trackers remain difficult to use due to calibration issues in particular. A poor calibration will make the data useless but even a good calibration tend to drift over time. Understanding the geometric models used in each solution might help us to build better gaze trackers and might also help users to avoid poor situations where calibration is most likely to fail. I will review some geometrical models used in video based techniques, explain their limitations, and also describe a few recent solutions towards a single, one time calibration per eye.

Alastair Gale

Loughborough University, UK

Alastair is Professor of Applied Vision Sciences and head of the Applied Vision Research Centre at Loughborough University. He holds a BSc and PhD from Durham University, researching with John Findlay. He is a: Chartered Psychologist; Fellow of the British Psychological Society; Fellow of the Institute of Ergonomics and Human Factors, and Honorary Fellow of the Royal College of Radiology. He researches primarily in medical imaging and has specialised in national breast cancer screening in the UK for over 25 years as well as working nationally in bowel and cervical cancer screening. Outside the cancer domains he has researched extensively into assistive technology, homeland security, gun crime, medication errors in e-prescribing, medical informatics and driving.

Recent interests include orthopaedic and laparoscopic surgery. He has published widely including editing 14 books and run many international vision conferences (including ECEM, twice!) in Europe, America and Australia. He runs the EM-LIST and organised (probably) the world's largest eye movement study with over 10,000 participants. He has won over €7m in solely authored research grants, plus contributed to another €6m in jointly authored grants. He is probably best known for alleging to never having worked a day in his life, just having an endless stream of accidental enthusiasms, and for ever wearing red shoes.

Abstract

A look inside the human body: the role of eye movements in medical imaging research

In 1895 Roentgen discovered the X-ray and produced the first X-ray image of his wife's hand. Fast forward 118 years to today and hospital medical imaging departments are awash with a multitude of different imaging techniques to produce appropriate insight into the innards of the human body. For many years X-ray images were produced as greyscale images on X-ray film which had to be viewed on illuminated light boxes in darkened radiological reporting rooms. Such film-based technology has now almost everywhere been replaced by digital imaging where images are captured and displayed digitally often using multiple very high resolution monitors. Interpreting the resultant images appropriately is in many ways an imperfect science and unfortunately errors have been, and are, made - often running at a rate of 20-30%. For the past 50 years many of these errors have been recognised as being due to failures of 'perception' (being taken in its most general sense) and a mass of international research has investigated many aspects of medical imaging with the aim of minimising error. Such research will be reviewed, together with current on-going work, and the problems of conducting meaningful real-world research in the domain today will be highlighted.

Kari-Jouko Räihä

University of Tampere, Finland

Kari-Jouko Räihä obtained his Ph.D. in Computer Science at the University of Helsinki in 1982. Since 1985 he has been a full professor of computer science at the University of Tampere, where he currently serves as the Dean of the School of Information Sciences. He has done research in applied eye tracking for more than 15 years. His primary interest is using eye gaze for computer control, both by users with motor impairments, and also in the context of attentive interfaces. He led the COGAIN Network of Excellence project, funded by the EU, in 2004-2009. He has twice been a co-chair of the ACM Symposium on Eye Tracking Research & Applications (ETRA).

Abstract

Computer Control by Gaze

Eye gaze has for a long time been used as an input channel for computer software. Early interest was directed at enabling the use of computers for users with disabilities that prevented other forms of communication. Later, applications that adapt their behavior based on the knowledge of the user's point of gaze, and interaction techniques specifically developed for gaze input, have attracted increasing attention. Recent emergence of low-cost trackers and mobile eye tracking technology, both in mobile handsets and in head-mounted glasses, has further accelerated the exploration of the possibilities offered by eye gaze as a computer input modality. I will review the work that has been done to make eye gaze a natural and enabling technique for interacting with computers.

Susana Martinez-Conde

Barrow Neurological Institute, United States of America

Susana Martinez-Conde received a BS in Experimental Psychology from Universidad Complutense de Madrid and a PhD in Medicine and Surgery from the Universidade de Santiago de Compostela in Spain. She was a postdoctoral fellow with the Nobel Laureate Prof. David Hubel and then an Instructor in Neurobiology at Harvard Medical School. Dr. Martinez-Conde led her first laboratory at University College London, and is currently the Director of the Laboratory of Visual Neuroscience at the Barrow Neurological Institute in Phoenix, Arizona.

Dr. Martinez-Conde's research bridges visual, oculomotor, and cognitive neuroscience. She has published her academic contributions in Nature, Nature Neuroscience, Neuron, Nature Reviews Neuroscience, and the Proceedings of the National Academy of Science, and written dozens of popular science articles for Scientific American. She writes a column for Scientific American: MIND on the neuroscience of illusions, and her research has been featured in print in The New York Times, The New Yorker, The Wall Street Journal, Wired,The LA Chronicle, The Times (London), The Chicago Tribune, The Boston Globe, Der Spiegel, etc., and in radio and TV shows, including Discovery Channel's Head Games and Daily Planet shows, NOVA: scienceNow, CBS Sunday Morning, NPR's Science Friday, and PRI's The World. She has collaborated in research and outreach projects with world-renowned magicians and is a member of the prestigious Magic Castle in Hollywood and the Magic Circle in London. She is the Executive Producer of the annual Best Illusion of the Year Contest, and collaborates with international science museums, foundations and nonprofit organizations to promote neuroscience education and communication. Her international bestselling book Sleights of Mind: What the Neuroscience of Magic Reveals About Our Everyday Deceptions has been published in 19 languages, distributed worldwide, and was listed as one of the 36 Best Books of 2011 by The Evening Standard, London.

Abstract

The impact of microsaccades on vision: towards a unified theory of saccadic function

When we attempt to fix our gaze, our eyes nevertheless produce so-called 'fixational eye movements', which include microsaccades, drift and tremor. Fixational eye movements thwart neural adaptation to unchanging stimuli and thus prevent and reverse perceptual fading during fixation. Over the past 10 years, microsaccade research has become one of the most active fields in visual, oculomotor and even cognitive neuroscience. The similarities and differences between microsaccades and saccades have been a most intriguing area of study, and the results of this research are leading us towards a unified theory of saccadic and microsaccadic function.

Alan Kingstone

University of British Columbia, Canada

Professor Alan Kingstone is a Fellow of the Royal Society of Canada, as well as a Distinguished Scholar and Head of the Department of Psychology at The University of British Columbia. His research publications include over 200 research articles, 2 textbooks on Cognition (Oxford Press), and edited books on Human Attention (Psychology Press) and Functional Neuroimaging (MIT Press). He is the co-Editor of the Annual Review in Cognitive Neuroscience (NY Academy of Sciences). His work has been funded by a number of agencies, including the Human Frontier Science Program, the Canada Foundation for Innovation, Social Science Health Research Council of Canada, the Canadian Institutes of Health Research, and the Natural Sciences of Engineering Research Council of Canada.

Abstract

The Cycle of Social Signaling

Social attention research is surprisingly anti-social. In the lab, research participants are routinely isolated and tested with simple social images that serve as proxies for real people. I will present recent work demonstrating that human social attention changes dramatically “in the wild” where people are in the presence of other real people. I suggest that a crucial difference between social attention ”in the lab” and social attention ”in the wild” is that, in the wild, individuals are faced with at least two, possibly competing, goals: (1) to attend to the social signals of other people, and (2) in doing so, broadcast social signals to others. Appreciating that this cycle of social signaling operates in the wild but rarely in the lab, is an important step towards gaining a broader understanding of human social attention.

Douglas P. Munoz

Queen's University, Kingston, Ontario, Canada

Douglas P. Munoz is the Director of the Centre for Neuroscience Studies and a Professor of Biomedical and Molecular Sciences at Queen's University in Kingston, Ontario, Canada. Doug was indoctrinated into eye movement research very early in his career. He completed a PhD in neurophysiology and eye movements in 1988 at McGill University and the Montreal Neurological Institute under the supervision of Daniel Guitton. He then moved to the National Eye institute in Bethesda, MD, USA to conduct postdoctoral studies with Robert Wurtz. In 1991, he joined the faculty of Queen's University where he developed a research program that included behavioural neurophysiology, human clinical studies, functional brain imaging, and computational modeling.

The common theme in all of the research projects is to study the saccade control system or use the saccade system to study brain function.

Abstract

Neural coding of saliency and coordination of the orienting response

The visual system must efficiently select crucial elements from the excessive information available in the environment for detailed processing. This selection process is greatly influenced by a bottom-up saliency-based mechanism, in which the saliency or conspicuity of objects (or locations) in the environment is encoded, and the appearance of a salient object can initiate an orienting response to allocate neuronal resources toward that object for computationally intensive processing. Saccadic eye movements and attention shifts, as components of the orienting response, are evoked by the presentation of a salient stimulus and are modulated by the stimulus saliency. The superior colliculus (SC) is a phylogenetically well-preserved subcortical structure, known for its central role in the initiation of eye movements and attention and in multisensory integration. The SC is also hypothesized to encode stimuli based upon saliency to coordinate the orienting response. In this presentation, I will review recent evidence showing a key role for the SC in coordinating orienting to salient stimuli. This includes modulations of eye movements, attention, and transient pupil responses.

Simon P. Liversedge

University of Southampton, UK

Simon Liversedge obtained his undergraduate degree and Ph.D. at the University of Dundee, before undertaking postdoctoral research at the Universities of Glasgow and Nottingham. He then became a Lecturer at the University of Durham where he taught cognitive psychology and continued his research in the eye movement laboratories. While at Durham he was promoted to Senior Lecturer then Reader before taking a Chair in Experimental Psychology at the University of Southampton where he co-directs the Centre for Vision and Cognition.

Liversedge's research interests lie in the field of cognitive psychology, and in particular eye movements, reading and visual cognition. He has used a number of different eye movement recording techniques to investigate a variety of aspects of human visual, linguistic and cognitive processing, though his research to better understand reading is probably most widely known. Some areas that he has investigated include oculomotor control during reading, binocular coordination during reading, children's reading, eye movement control in dyslexia and reading in non-alphabetic languages. Liversedge works collaboratively with colleagues both nationally and internationally.

Abstract

Rethinking Theoretical Frameworks: Studies of Eye Movements During Non-alphabetic Reading and reading development

In cognitive psychology there has been a significant amount of eye movement research to investigate the psychological processes underlying normal reading. The vast majority of this work has focused on skilled adult reading of alphabetic languages (predominantly English). However, recently, two areas have received an increasing amount of attention; reading in non-alphabetic languages, and the study of reading development. The main claim that I will make in this talk is that consideration of experimental findings from studies in these areas pushes us to think somewhat differently about the theoretical questions we pursue in our work. To make this claim, I will discuss data from a number of relevant experiments that colleagues and I have carried out, focusing on key theoretical issues that have emerged from the work. I will also try to consider the implications of these findings for existing accounts of eye movement control in reading.

Thomas Haslwanter

Upper Austrian University of Applied Sciences

After starting his career with an undergraduate physics degree in quantum optics (from the University of Innsbruck, Austria, in 1988), Thomas Haslwanter switched for his graduate degree (at the Swiss Federal Institute of Technology, ETH, in Zurich, Switzerland, in 1992) to the field of Neuroscience, with work on the control principles of eye-, head- and arm-movements. During his post-doctoral research stays at the Dept. of Psychology, University of Sydney, Australia (1992-1995) and at the Dept. of Neurology, University of Tübingen, Germany (1995-1998) he focussed on the recording of 3-dimensional eye movements, with search coils as well as with video, and on its applications to medical diagnosis. With a strong interest in mountaineering and climbing, he returned to Zurich for his habilitation in the field of biophysics (ETH Zurich, 2001). In 2004 he moved back to Austria. After two years as Head of Research at the Dept. of Medical Informatics at "Upper Austrian Research", he got a professorship at the Dept. of Biomedical Engineering, at the Upper Austrian University of Applied Sciences, and has been working since. His current research interests focus on video-based measurement of 3D eye movements, 3D movement kinematics, and interactive rehabilitation.

Abstract

Eye movements in medical research and application

The last fifteen years have seen a revolution in the field of eye movement recording. Before then, accurate recordings of eye movements were pretty much restricted to electro-oculography (EOG), and to the use of scleral search coils, the gold standard in ocular motor research. Purkinje trackers were (and still are) restricted to the recording of small eye movements in research labs, and more exotic devices were invented, but never really caught on. Nowadays, eye movement recording is done almost exclusively with video-based systems, also called eye trackers. In medicine, these systems are called video-oculography (VOG). EOG and scleral search coils are only used for special applications, such as sleep research, or the investigation of high speed saccades. However, many underlying problems of VOG systems have remained unsolved, such as the slippage of cameras with respect to the head, or small translations of the eyeball in the orbit, and it is helpful to keep in mind the strengths and limitations of each of the eye movement recording techniques.

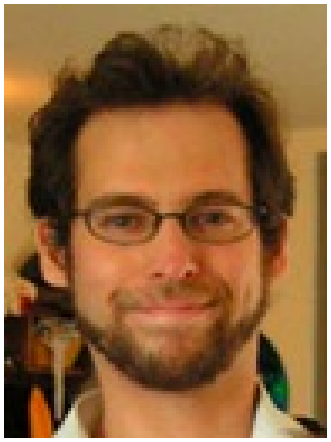
In the first part of this talk, Thomas Haslwanter and Erich Schneider will present the development of the different techniques for eye movement recording, and their strengths and weaknesses. For the last 80 years, eye movement recording has stayed closely to the leading edge of measurement technology, and the history of eye movement recording closely mimics the progress in measurement technology. In the second

part of the talk, we will present examples of the application of eye movement recording in two of the leading medical research centers, at the University Hospitals in Munich, Germany, and in Zurich, Switzerland. In both these places, eye movements are commonly recorded with VOG, with other techniques restricted to limited special applications.

In contrast to research in the fields of psychology and human computer interaction, where researchers are typically interested in the location of the visual target, often under relatively static conditions, medical diagnosis typically requires an analysis of the velocity of the movement of the eye within the head, under static as well as dynamic conditions. This puts different requirements on the measurement technology. The talk will present the state of the art of clinical eye movement recording, where the most recent developments have been the adaptation of high speed VOG systems, for the measurement of eye movements under dynamic conditions. Eventually, open research questions will be discussed, followed by a short outlook on pending developments.

Daniel Richardson

University College London, UK



Daniel Richardson is a Senior Lecturer in the department of Cognitive, Perceptual and Brain sciences at UCL. His lab uses gaze, speech and motion tracking technology to investigate how perception and cognition are embedded in the social world. Before coming to UCL, Daniel was an undergraduate at Magdalen College, Oxford, a graduate student at Cornell, a postdoctoral researcher at Stanford, and an assistant professor at the University of California, Santa Cruz. He was fleetingly on the television as part of a BBC documentary, and recently received the Early Career Provost's Teaching Award at UCL.

Abstract

Gaze and Social Context

Social interaction, social context and emotional goals can exert a strong influence on eye movements. These effects can be seen in a range of situations, from two people engaged in a conversation, to one person, in isolation, looking at a set of faces. In this talk I will present a range of experiments exploring these phenomena, and make some tentative proposals regarding the way that social forces shape visual attention.

In one set of experiments, two participants in adjacent cubicles had a discussion over an intercom, and we used cross recurrence analysis to quantify the coordination between their gaze. Coordination was modulated by what they thought each other knew, and what they thought each other could see. Later we used the tangram task to reveal how participants gradually coordinated their knowledge, their reference scheme and their gaze patterns. In a second set of experiments, we showed that participants do not even need to interact for social context to influence gaze. We showed sets of four images to pairs of participants who were sat back to back. They looked differently if they believed that the other person was looking at the same images as them, or a set of random symbols. Even when someone is alone in a lab, social forces are at work. When looking a picture of a face, work from our own lab and others has revealed that scanpaths are determined by the mood, personality, culture, status and sex of both the viewer and the face they are viewing. If there is any commonality across these diverse phenomena, it seems that gaze in a social context is functioning not purely as a perceptual input, but as a tool to coordinate social interaction.

Panel discussions

Room: Stora salen

Panel discussion 1

Data quality

Monday, August 12, 18:50 - 20:00

Chair: Kenneth Holmqvist

How to measure data quality? Can it be objectively reported? What effect does data quality have on research?

Panel discussion 2

The Merits of Experimental and Observational Designs in Eye-Movement Research

Tuesday, August 13, 18:50 - 20:00

Chair: Reinhold Kliegl

(1) Divergence/convergence of results with respect to theoretical issues such as lag and successor effects in reading (2) (Traditional) ANOVA statistics vs. (recent) multivariate alternatives (LMMs, GLMMs, GAMMs) (3) Issues relating to replication (statistical power) (4) Relation to basic research, applied research, and use-inspired basic research

Panel discussion 3

Using eye movement parameters to diagnose neurological disease - something for clinical practitioners or evidence of a fundamental neurological and oculomotor relationship relevant to all eye movement research?

Thursday, August 15, 18:50 - 20:00

Chair: Douglas P. Munoz

In clinical eye movement research, a number of robust measures have been developed, such as the anti-saccade paradigm and the smooth pursuit measures. Can and should these measures and paradigms be used more generally in psychological research, to control for participants' individual traits?

Panel discussion 4

Future directions for eye movement research and applications

Friday, August 16, 14:30 - 15:30

Chair: Carlos H. Morimoto

Eye-tracking changes: New research areas emerge. Both hardware and software are different, and new applications arrive that become products. More people are using eye-trackers. How do we best prepare for the future?

Talks

High-level processes in reading I

Monday, August 12, 10:20 - 12:00

Room: Stora salen

Chair: Jukka Hyönä

Processing task-relevant information shrinks momentarily readers' perceptual span

Jukka Hyönä & Johanna K. Kaakinen
University of Turku, Finland

Expository texts were read for comprehension from a spesific perspective that made some text information highly relevant to the assigned perspective while most text information remained perspective-irrelevant. We investigated how text relevance influences the useful visual field in reading by using the eye-contigent display change paradigm. A word in task-relevant and task-irrelevant sentences was initially replaced with a random letter string (the initial letter was preserved). During the saccade into the target word the incorrect parafoveal preview was changed to the correct word form. The results based on data collected from 40 adult readers' showed the duration of single fixation on Word N-1 (parafoveal-on-foveal effect) depended on task relevance. When the word belonged to a perspective-irrelevant sentence, a reliable preview effect (the change condition producing longer fixation durations than the identical condition) was observed, whereas there was no preview effect for the targets being a part of perspective-relevant sentences. A similar pattern was obtained for the first fixation and gaze duration on the target word (parafoveal preview effect). These data demonstrate that when reading task-relevant information, readers' perceptual span is shrinked (less parafoveal processing is carried out). The study demonstrates that task demands influence the useful visual field during reading

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Individual differences in the online processing of written sarcasm and metaphor

Henri Olkoniemi, Johanna Kaakinen, Henri Ranta & Jukka Hyönä
University of Turku, Finland

To date, very few studies have directly compared processing of different forms of figurative language. The purpose of the present study was to compare on-line processing of texts that include literal, sarcastic and metaphorical sentences, and to examine individual differences in figurative language processing. Sixty participants read sarcastic, metaphorical and literal sentences embedded in text while their eye movements were recorded and sentence-level measures were computed from the data. Individual differences in working memory capacity, cognitive style, cognitive-affective processing and theory of mind were also measured. The results showed that metaphors are resolved immediately, during first-pass reading, whereas sarcasm produces mainly delayed effects in the eye movement records. Moreover, individual differences in the processing of sarcasm were observed. The results have implications for current theories of figurative language comprehension.

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Why can't we kick the seau and break the glace? An eye movement study of idiom code-switching

Debra Titone, Georgie C. Columbus & Lianne Morier
McGill University, Canada

Idioms (kick the bucket, spill the beans) exemplify a larger class of multiword expressions (MWEs) as they vary along all linguistic dimensions relevant to MWEs generally (familiarity, compositionality, ambiguity). Open questions are whether idioms are processed via direct retrieval, compositional analysis, or both (e.g., Libben & Titone, 2008), and whether first vs. second language readers process idioms differently. We investigated these questions in 43 English-French and 38 French-English bilinguals who read sentences containing idioms or control phrases presented in an intact or code-switched manner (kick the bucket vs. kick the seau). Bilinguals reading in their L1 showed clear evidence of direct retrieval: they showed greater code-switch costs for idioms vs. control phrases in both first pass and total reading measures, and were sensitive to differences among idioms in familiarity rather than compositionality. Bilinguals reading in their L2, however, showed evidence of both direct retrieval and compositional processes: they showed smaller idiom code-switch costs, and were sensitive to differences among idioms in cross-language overlap and compositionality. These data are consistent with hybrid or constraint-based models (Titone & Connine, 1999; Libben & Titone, 2008), which propose that direct retrieval and compositional processing contribute to idiom processing in a time- and knowledge-dependent manner.

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Processing trigrams: Eye movements in formulaic language reading

Georgie C. Columbus[1], Patrick Bolger[2], Cyrus Shaoul[3] & Harald Baayen[4]
[1]McGill University, Canada
[2]University of Southern California, USA
[3]University of Tübingen, Germany
[4]University of Tübingen, Germany

Multiword units (MWUs) are frequently co-occurring word combinations that include idioms, restricted collocations and lexical bundles. Idioms are the most-studied form of MWUs, though it remains unclear whether they, or the general class of MWUs, are processed via direct retrieval, compositional analysis, or both (e.g., Libben & Titone, 2008; Gibbs & Nayak, 1989; Cacciari & Tabossi, 1988). We investigated these questions in 19 native English speakers who read 1000 decontextualized three-word phrases that included idioms, restricted collocations and lexical bundles while their eye movements were monitored. Eye movement measures showed clear evidence of both compositional (i.e., component word frequency effects) and direct retrieval (i.e., phrase frequency effects). In support of compositional processing, increased word frequency facilitated both first pass and total reading measures. In support of direct retrieval, increased phrase frequency slowed first pass reading, suggesting that phrasal processing interfered with component word processing, but later facilitated total reading time. These results are consistent with past work on idioms and MWUs, and cohere with hybrid or constraint-based models of formulaic language (Titone & Connine, 1999; Libben & Titone, 2008), according to which direct retrieval and compositional processes both contribute to formulaic language understanding in a time- and knowledge-dependent manner.

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Measuring the Impact of Hyperlinks on Reading

Gemma Fitzsimmons, Mark Weal & Denis Drieghe
University of Southampton, United Kingdom

It has been suggested that the presence of hyperlinks embedded into Web pages has a negative influence upon reading behaviour on the Web (Nielsen, 1999; Carr, 2010). We conducted a study where participants were asked to read edited Wikipedia articles while their eye-movement behaviour was recorded. Target words (high or low frequency) were embedded in sentences and either displayed as hyperlinks (coloured in blue) or as normal text. A prior control study on the same subjects ensured that colouring target words outside of a Wikipedia/Web context had no influence upon reading behaviour. Participants were asked to read for comprehension but were unable to click any links. Analyses demonstrated that hyperlinks had no early effects on reading behaviour but re-reading increased when the target word was a hyperlink and low frequency. In all likelihood, the suggestion of additional information concerning the target word (i.e. hyperlinking to other explanatory Web pages) combined with its lexical difficulty (i.e. low frequency) caused our participants to re-analyse previous text sections.

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Talks

Special symposium on eye tracking research on subtitling

Monday, August 12, 10:20 - 12:00

Room: Nya fest

Chair: Izabela Krejtz

Processing Information Overload in Subtitling for the Deaf and Hard-of-Hearing

Verónica Arnáiz-Uzquiza
Universidad de Valladolid / CAIAC-Transmedia Catalonia, Spain

Subtitling for the Deaf and Hard-of-Hearing (SDH) is an especially demanding task for both intended viewers and subtitlers. On the one hand, the search for a complete comprehension of (audio)visual contents makes hearing impaired audiences dependent on the visuals; on the other hand, practitioners, exposed to simultaneous channels and sources of information, need to discriminate contents for the creation of effective subtitles. When confronted with sound information overloads -concurrence of different types of extralinguistic features (paralinguistic information, music and sound representation), or even the simultaneous representation of a single type-, SDH professionals adopt subjective criteria for their conveyance. This paper will focus on an eye-tracking study aimed at analyzing how SDH-based perception results in the comprehension of a truncated and altered final scene. Three groups –a hearing group, another group with hearing viewers under deafened conditions, and a final group of hearing-impaired viewers- were exposed to a series of subtitled and non-subtitled videos with sound information overload. Results confirmed how current practices for the conveyance of extralinguistic features bias viewers' natural reading behaviour and visual processing, leading to contrasting scanpaths, attention allocation and content comprehension among deaf and hearing impaired audiences.

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Time to read, time to watch: Eye movements and information processing in subtitled films.

Anna Vilaro[1], Pilar Orero[2], Tim J. Smith[3]
[1]CAIAC, Universitat Autonoma de Barcelona, Spain
[2]CAIAC, Universitat Autonoma de Barcelona, Spain
[3]Birkbeck, Univeristy of London, UK

Watching foreign-language media is part of our everyday lives. Techniques such as subtitling or dubbing provide the verbal information to foreign linguistic communities. To study the implications of these techniques on the information that viewers gather from the audiovisual scene, 24 English speakers watched 8 movie clips in 4 possible versions of language and subtitles: (EA-NS) English audio without subtitles; (SA-NS) Spanish audio, without subtitles; (SA-ES) Spanish audio with English subtitles; and (EA-SS) English audio with Spanish subtitles. Eye movements were recorded and analyzed relative to dynamic regions of interest. A questionnaire assessed the recall of visual and verbal information. Results show that the region corresponding to the subtitles was fixated significantly longer when clips were presented in SA-ES version compared to other conditions, confirming that participants read the subtitles. Nevertheless, participants spend most of the time fixating actor faces, and to a lesser extent other items appearing in the scene. The effect of presenting subtitles has an effect on the time dedicated to observe faces, however the decrease in the observation time does not affect the recall performance for scene items and dialogue information, suggesting that dubbing and subtitling are equivalent in terms of the important narrative information processed.

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Effects of Shot Changes on Eye Movements in Subtitling

Agnieszka Szarkowska[2] & Izabela Krejtz[1]
[1]University of Social Sciences and Humanities, Poland
[2]University of Warsaw, Poland

In this paper we address the question whether shot changes trigger the re-reading of subtitles. It has been widely accepted in the professional literature on subtitling that subtitles should not be displayed over shot changes, however support for this claim in eye movement studies is hard to find. In order to verify whether shot changes increase the tendency of re-reading of subtitles, we examined eye movement patterns of participants (N = 67) watching feature and documentary clips. We analyzed number of deflections between subtitles displayed over shot changes and those which do not cross any shot changes, first fixation duration on subtitle beginning before and after the shot change, the number of transitions between AOIs, and dwell time on two line subtitles that cross over a shot change. Results of our study show that most viewers do not re-read subtitles which are maintained over shot changes.

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Attention distribution in academic lectures: eye tracking and performance

Jan-Louis Kruger, Este Hefer & Gordon Matthew
North-West University, South Africa

The way students distribute their visual and cognitive attentional resources during an academic lecture is of paramount importance in educational design. When attending to (or watching a recording of) an academic lecture, students constantly have to shift their attention between different sources of information of varying information density and relevance. If there is redundancy between the words spoken by a lecturer, information on a visual presentation, and a transcription or translation of the words of the lecturer in subtitles, there will necessarily be competition, and a risk of cognitive overload.

In this paper we will report on an eye-tracking study conducted on one recorded lecture from a first-year Psychology class. The main focus will be on a comparison of visual attention distribution (derived from eye tracking data) between subtitles, slides, and the lecturer (information-rich sources) and the rest of the screen (information-poor source). The eye tracking data will be correlated with performance and brain activity measures to determine the impact of attention distribution between different sources of information on academic comprehension and engagement. We will engage critically with studies that either consider subtitles beneficial to learning because of dual coding, or disruptive to learning because of cognitive overload.

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Live Subtitling with Punctuation-Based Segmentation: Effects on Eye Movements

Andrew Duchowski[1], Juan Martinez[2] & Pablo Romero-Fresco[3]
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We report on two studies testing subtitle segmentation during simulated live subtitling (respeaking). The first study compared simulated live subtitles where scrolling preserved grouping of phrases or of sentences against word-for-word subtitle scrolling and against blocked subtitling (the control condition). Within-subjects ANOVA showed a significant difference in the number of saccadic crossovers (raw gaze transitions between screen and text), with the largest number occurring during word-for-word scrolling. No differences in preference or comprehension were observed. The second study tested the effects of punctuation-based subtitle segmentation on the viewing experience of the deaf and hard-of-hearing (word-for-word scrolling was omitted). Between-subjects analysis of filtered gaze data (fixations) revealed no significant effects of subtitle segmentation or of demographics, but a trend was observed where sentence-based segmentation elicited a smaller proportion of fixations on text. Although sentence-based segmentation drew complaints regarding latency, this style of segmentation appears to be preferred by viewers due to their resemblance to traditional, blocked subtitles.

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Talks

Driving and transportation

Monday, August 12, 10:20 - 12:00

Room: Lilla salen

Chair: Björn Peters

Looking where You are Going – the Future Path vs. the Tangent Point as Car Drivers' Gaze Target

Otto Lappi, Esko Lehtonen & Jami Pekkanen
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In curve driving, orientation towards the future path (FP) and/or the tangent point (TP) have been identified as the predominant gaze targets of guiding fixations. Several steering models could, however, account for the pattern of tangent point orientation because in typical curves the TP and many reference points on the FP fall within a few degrees of the tangent point. Yet for twenty years "steering by the tangent point" has been the dominant default hypothesis for interpreting gaze behavior during curve negotiation. One possible reason is the technical challenge of representing "the future path" parametrically in real on-road gaze behavior data. Here, data is presented from two experiments where orientation toward the future path was explored in terms of two complementary methods of representing parametrically the future path in real on-road data. The results show that while gaze is, indeed, often near the tangent point, the drivers scan the road surface in the far zone (beyond the tangent point), consistent with targeting points on the future path. The findings are discussed in terms of steering models of driver behavior, as well as neural levels of oculomotor control in visually oriented locomotion.

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Oculomotor Signatures of Cognitive Distraction

Steven William Savage, Douglas Potter & Benjamin Tatler
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The aim of our research is to determine whether eye movement metrics can be used to infer a driver's current cognitive load. As secondary visual and cognitive task demands have been shown to influence driving performance in qualitatively different ways it is important to isolate each in order to study their effects on driving performance.

Eye movements are intimately linked to the allocation of attention. Thus if high cognitive load interferes with attention networks, we would expect to see changes in eye movement behaviour as a result. We tested the hypothesis that contemplating a recent mobile telephone conversation has a detrimental effect on measures of attentional processing during a hazard perception task (Savage, Potter & Tatler, 2013). We found significant increases in blink frequencies, higher saccade peak velocities and a significant reduction in the spread of fixations along the horizontal axis in the high cognitive task demand condition.

We argue that changes in certain oculomotor metrics are indicative of increases in cognitive task demand. This work not only identifies eye movement markers of cognitive distraction, but also provides a first step toward using eye movement behaviour as a diagnostic tool with which to identify driver cognitive distraction.

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Influence of road conditions on car drivers gaze behavior with on-road vehicle tests

Rui Fu[1], Yong Ma[2], Ying-shi Guo[2], Wei Yuan[2], Chang Wang[2] & Fu-wei Wu[1]

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Driver's gazing behavior is of great importance to safe driving. To analyze the influences of road conditions on car driver's gazing behavior, based on the division of driver's fixation areas and the classification of visual objects, 20 drivers' eye movement data and gazing behaviors were tested and recorded by EyeLink II eye tracker in the condition of driving on urban roads, suburban roads and mountainous highways. Drivers' gazing behavior characteristics in different types of roadways were studied based on the analysis of test data, such as distribution of fixation frequencies in each area or for different objects, vertical visual angles and visual distances, and mean fixation duration (MFD) of objects etc. The results indicated that, road condition significantly affect driver's fixation frequencies and MFDs on different areas and objects. Drivers adjust their visual behavior according to the changes of road environment or traffic conditions. When driving in relatively simple road traffic environment, drivers watch farther and the MFD is shorter, while in complex environment, drivers watch closer and the MFD is longer. The findings laid experimental basis for in-depth study of driver visual behavior laws and traffic safety.

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The effect of hearing loss on eye movements when driving and an evaluation of tactile support for navigation

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A field study was conducted to evaluate the use of a tactile signal in addition to a navigation system and to examine the effect of hearing loss on eye movements. 32 participants took part in the study (16 with moderate hearing loss and 16 with normal hearing).

Each participant performed two preprogrammed navigation tasks while driving a X km route. In one, participants received only visual information from the navigation system, while the other also included a vibration in the seat to guide the driver in the correct direction. The order in testing was balanced over the participants.

SMI glasses were used for eye tracking, which records the point of gaze within the scene. Frame by frame analysis analyzed predefined regions of interest within the scene, e.g. the mirrors, the speedometer and the navigation display. A questionnaire also examined participant's experience of the two navigation systems after their driving tasks

Results revealed that hearing loss was associated with lower speed, higher satisfaction with the tactile signal and more glances in the rear view mirror. Additionally, tactile support lead to less time spent viewing the navigation display, regardless of hearing status.

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Identification on drivers' lane change intent via analysis of eye movement features

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To improve the performance of existing lane change assistant system, a novel method of identifying driver's lane change intent was developed based on driver's eye movement analysis. Driving tests were carried out in real-world road environment. By monitoring lateral positions and steering angles of the test vehicle, the beginning time of lane change was identified. By analyzing driver's glances to the rear-view mirror before lane change initiation, the optimum time range which can represent driver's lane change intent (also called characterized time window length) was determined. The eye movement features (such as mean fixation duration, mean saccade amplitude etc.) differences between the lane keeping stage and the lane change intent stage were explored. On this basis, a characterization system for driver's lane change intent was constructed. The results indicate that the lane change characterized time window length is 5 s, during which driver's glances characteristics to rear-view mirror can best reflect the lane change intent. There are significant differences of eye movement features between the lane keeping stage and the lane change intent stage. Driver's lane change intent can be effectively identified with eye movement features.

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Talks

Action and language mediated vision

Monday, August 12, 10:20 - 12:00

Room: Sångsalen

Chair: Helene Kreysa

Eye movements during simple sequential sensorimotor tasks: Evidence against benefits of eye-hand guidance

Rebecca M. Foerster & Werner X. Schneider
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In many serial sensorimotor tasks, the eyes precede the manual movements in space and time. It is an open question whether these eye movements are necessary for effective manual control. We asked participants to click as fast as possible on numbered circles in ascending order on a computer screen (number connection task). During an acquisition phase, participants performed 100 trials with the same spatial arrangement of 8 numbered circles. In the consecutive retrieval phase, participants had to click on an empty screen in the same order as during the acquisition phase. Participants were divided into four gaze instruction groups: Free gaze, central fixation during acquisition, central fixation during retrieval, and central fixation throughout the experiment. Results revealed, first, better hand performance with than without visual information on the screen. Secondly, no performance differences were found across the gaze instruction groups. However, participants had enormous problems not to move their eyes, so that on average 7 trials had to be abandoned before one trial was completed with central fixation. We conclude that saccadic eye movements are not necessary for the acquisition and retrieval of simple serial manual actions, but maintaining fixations in these tasks seems rather difficult and effortful.

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Modeling of oculo-manual guiding eye movements

Saulius Niauronis, Raimondas Zemblys & Vincas Laurutis
Siauliai University, Lithuania

The task of guiding a hand moved object through a path employs slightly different eye movements than those seen in oculomotor-only behaviour. The main reason for this is the need for eye-hand coordination. In previous works we introduced an extended qualitative model of eye-hand coordination, based on simulation-proved qualitative models. This model is suitable for modelling oculo-manual behaviour during an object guiding through a visible complex path. On a way towards quantitative model, the critical part, relating the eye movements to the visual path and the hand-moved object is further explained. Also the probabilistic parameters, defining the eye movement timing and amplitudes related to hand-moved object position, complexity of the path in sight and psychologically chosen speed to precision ratio, were experimentally determined and discussed.

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The effects of featural and spatial language on gaze cue utilisation in the real world

Ross G. Macdonald & Benjamin W. Tatler
University of Dundee, United Kingdom

Gaze cues are used in conjunction with spoken language to communicate. Previous research using a real-world paradigm has shown an interaction between language and gaze cue utilisation, with gaze cues being used more when language is ambiguous. The present study investigates whether gaze cue utilisation is affected, not by the specificity of language, but by the form of language. More specifically, we are interested in whether the use of spatial or featural disambiguating determiner words affects the extent to which people use gaze cues. Each participant followed instructions to complete a real-world search task, whilst wearing a portable eye-tracker. The instructor varied the determiner used (spatial or featural) and the presence of gaze cues (congruent, incongruent or absent). Fixations to the objects and instructor were recorded. Incongruent gaze cues were not initially followed any more than chance. However, in comparison to the no-gaze condition, participants in the incongruent condition were slower to fixate the correct object for instructions with spatial determiners only. We suggest that although participants can inhibit gaze following when cues are unreliable, visual search can nevertheless be disrupted when inherently spatial gaze cues are accompanied by contradictory verbal spatial determiners.

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Integration of Eye Movements and Spoken Description for Medical Image Understanding

Preethi Vaidyanathan, Jeff Pelz, Cecilia Alm, Cara Calvelli, Pengcheng Shi & Anne Haake
Rochester Institute of Technology, United States of America

Examining medical images to identify and characterize abnormalities is a complex cognitive process learned through training and experience. Eye movements help us understand medical experts perceptual processes and co-occurring spoken narration reveals conceptual elements of such cognitively demanding tasks. We believe that defining the temporal asynchrony (i.e. time-lag) between gaze and lexical naming during medical image inspection can help us understand the salient image regions (and meaningful features) that assist in performing image-based diagnosis. Our investigation reveals statistically significant differences in the gaze-verbal reference time-lag for image complexity (in terms of how difficult the case was to diagnose based on the image), and type of clinical attribute (primary vs. secondary attribute), but not a difference by individual experts. Additionally, the perceptual gaze systematically preceded the lexical reference, irrespective of other factors. We also report on a method to integrate visual (perceptual) and linguistic (conceptual) data that jointly allows objective observation that mirrors experts' cognitive processes.

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Using eye tracking to confirm the influence of language on thought

Victoria Hasko
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The presentation addresses one of the most long-standing debates in cognitive sciences pertaining to whether the language that we speak influences the way that we think. The controversy is far from being resolved, as the majority of evidence in support of such influence is informed by purely verbal tasks. However, to confirm the ubiquity of the proposed hold of language on thought, it is necessary to provide additional evidence from non-verbal behavioral tasks, and this is precisely the goal of the reported cluster of studies which investigate verbal and non-verbal behavior of English vs. Russian speakers as they attend to, memorize, and verbalize motion events presented on a computer screen (video clips and images). The two languages differ significantly in the way that they encode motion events, and the reported cluster of studies a) confirm linguistic disparities in the verbalization patterns employed by the two speaker groups; and additionally report differences in their non-verbal behavior on b) a memory and c) perception tasks. Non-verbal behavior is measured through eye tracking methodology via analysis of the overall number of fixations in AoI (trajectory and endpoint of motion), fixations in AoI (total gaze), and fixations in AoI in the first pass.

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Talks

High-level processes in reading II

Monday, August 12, 14:30 - 15:50

Room: Stora salen

Chair: Prakash Padakannaya

Eye movement measures while reading English and Kannada alphasyllabary

Prakash Padakannaya & Aparna Pandey
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Eye tracking studies are useful for examining several interesting questions related to the language/orthography variables such as how grain size and transparency of orthography as well as lexical, syntactic or morphological features influence eye movements. However, there are not many cross-orthographic studies available focusing on the effect of orthographic differences on eye movement patterns though such studies may yield significant results delineating universal and language/orthographic specific aspects of reading. The present study compared eye movement measures of English-Kannada biliterates while reading simple, complex, and jumbled sentences matched on length and difficulty levels. English and Kannada vary in terms of grain size and transparency besides differing on such linguistic properties as syntax and morphology. While English is an opaque alphabetic orthography, Kannada is a transparent alphasyllabary. Kannada is also agglutinative language that follows subject-object-verb canonically but allowing rather free word order with the use of case markers. The results showed that orthography as having significant effect on eye movement measures. Further, the results on English showed significant differences between jumbled and well-formed sentence conditions. Kannada results did not show such significant differences. The results are discussed in terms of the orthographic differences and linguistic differences between the languages.

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Lexical Entrenchment vs. Cross-Language Competition Accounts of Bilingual Frequency Effects: Two Sides of the Same Coin?

Veronica Whitford[1,2] & Debra Titone[1,2]
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Eye movement measures of bilingual reading show differential first- (L1) and second-language (L2) word frequency effects (FEs) within and across bilinguals (Whitford & Titone, 2012). Whether such effects arise from reduced lexical entrenchment given divided L1/L2 exposure, cross-language competition, or both is an open question. We thus investigated whether current L2 exposure, which affects lexical entrenchment in a manner similar to word frequency, and non-target-language neighbourhood density, which reflects cross-language competition, modulate L1 and L2 FEs in 86 French-English bilinguals as they read extended L1 and L2 paragraphs. We hypothesized that lexical entrenchment and cross-language competition would interact such that the likelihood of competition would be maximal under conditions of low lexical entrenchment. Replicating our prior work, linear mixed-effects models for gaze duration revealed larger L2 vs. L1 FEs, and larger L1 FEs in bilinguals with high vs. low L2 exposure. Of note, cross-language competition occurred for low-frequency L2 words exclusively, such that increased L1 neighbourhood density resulted in shorter gaze durations for low-frequency L2 words, irrespective of current L2 exposure. This suggests that lexical entrenchment and cross-language competition may be two sides of the same coin with respect to bilingual reading, as they mutually constrain each other.

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Eye movements while reading interlingual homographs: The relative influences of semantic and language contexts

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While previous studies have examined the individual influences of semantic and language contexts on bilingual interlingual homograph (ILH-–words with similar orthography, but different meanings across languages) processing, the interaction and relative influences of these different contextual sources remain unclear. In the present study, we recorded readers' eye movements to examine reading time measures on English sentences containing Spanish/English ILHs. We held language context constant (English-–bilingual participants' L2) and manipulated whether the pre-ILH semantic context biased the L1 interpretation of the ILH or was neutral. When the pre-ILH semantic context biased the Spanish interpretation, reading times were shorter on the ILH relative to when the pre-ILH semantic context was neutral. Longer reading times were found in the post-ILH region when ultimately only the English interpretation of the ILH was supported by the context. Though language context always biased the bilinguals' L2, we observed decreased reading time on the ILH following a semantic context that biased the bilinguals' L1. Shorter reading times after a biased semantic context, followed by increased reading times after post-ILH disambiguation, suggests that readers initially interpreted the ILH based on the semantic context, consistent with a greater influence of semantic context relative to language context.

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PopSci: A reading corpus of popular science texts with rich multi-level annotations. A case study

Sascha Wolfer[1], Daniel Müller-Feldmeth[1], Lars Konieczny[1], Uli Held[1], Karin Maksymski[2], Silvia Hansen-Schirra[2], Sandra Hansen[1], Peter Auer[1]
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We introduce a reading corpus comprised of 16 German texts taken from popular science journals. Texts cover several natural science topics and vary in complexity and length. The PopSci corpus is annotated with rich information on lexical, syntactic and pragmatic levels. Reading time measures were computed not only for word tokens but also for larger regions derived from all levels of annotation.

We present an analysis investigating the relation between depth of embedding and reading time. Pynte et al. (2008) found that content words are being read faster if they are embedded deeper. We replicated this effect in the PopSci corpus, using dependency structure as the level of analysis. A more fine-grained analysis revealed that this effect is mainly due to the increased processing speed for arguments and modifiers. For clausal and verb nodes, deeper embeddings showed higher first-pass reading times. We argue that this finding indicates interference from pre-verbal nouns and pronouns regardless of their level of embedding, as suggested by cue-based retrieval theories.

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Talks

Parafoveal word segmentation in reading

Monday, August 12, 14:30 - 15:50

Room: Nya fest

Chair: Denis Drieghe

Parafoveal Preview Effects In Reading Unspaced English Text

Denis Drieghe, Gemma Fitzsimmons & Simon P. Liversedge
University of Southampton, United Kingdom

In English reading, eye guidance relies heavily on the spaces between the words for demarcating word boundaries. In an eye tracking experiment during reading, we examined the impact of removing spaces on parafoveal processing. A high or low frequency word n was followed by word n+1 presented either normally, or with all letters replaced creating an orthographically illegal preview. The spaces between words were either retained or removed. Results replicate previous findings of increased reading times and an increased frequency effect for unspaced text (Rayner, Fischer & Pollatsek, 1998). On word n a reduced viewing time was observed prior to the incorrect preview but this parafoveal-on-foveal effect was restricted to the unspaced conditions. Preview effects on word n+1 were substantially modulated by frequency of word n, but again only in the unspaced conditions: The incorrect preview resulted in longer viewing times on word n+1 when word n was high frequency but paradoxically shorter when word n was low frequency. In all likelihood, the unusual letter combination facilitated detection of the word boundary for the low frequency word, allowing for more focused processing of word n. Implications for views on word boundary resolution will be discussed.

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Using visual and linguistic information as segmentation cues when reading Chinese text: An eye movement study

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Chinese text is traditionally printed without interword spaces, and the means by which readers identify word boundaries is unclear. We examined the influence of two segmentation cues – word spacing, and the positional frequencies of constituent characters – on lexical processing during sentence reading. Participants read sentences containing two-character pseudowords embedded within explanatory sentence frames, in a learning and a test phase. Thus, we examined the effects of our manipulations on the process of identifying word boundaries without the influence of top-down processing from existing lexical representations. There were three types of pseudowords, dependent on the positional frequencies of their constituent characters: balanced, congruent, and incongruent. Each pseudoword had six sentence frames, three each for the learning and test phases. In the learning phase, half the participants read unspaced text and the other half read word-spaced text. In the test phase, all participants read unspaced text. The spacing manipulation facilitated word processing in the learning phase, but this was not maintained in the test phase. The positional frequency manipulation also affected word processing, but there was no significant interaction between spacing and positional frequency manipulations. These data will be discussed within the context of models of Chinese lexical identification.

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Processing-based eye movement strategy in Chinese reading

Xingshan Li
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In English reading, readers' eyes typically land on a fixed location on a word, which is halfway between the beginning and the middle of the word. English readers could do so because there are spaces between words so that English readers could perceive word boundary information based on low-level visual information. In contrast, in Chinese reading, there are no inter-word spaces between words. In this situation, how do Chinese readers decide where to move their eyes? In one of the studies, we showed that the landing position was not affected by the length of the target word, suggesting that Chinese readers do not target at any specific position within a word when they move their eyes. In another study, we showed that the length of saccades leaving an "easy" word was longer than leaving a "difficult" word. Based on these findings, we propose a processing-based strategy for saccade target selection in Chinese reading. According to this strategy, readers identify as many characters as possible on each fixation. As a consequence, the easier the processing of the fixated word, the longer the outgoing saccade. Simulation results show that a computational model based on this strategy could predict most eye movement results in Chinese reading.

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Character position encoding in Chinese reading

Junjuan Gu & Xingshan Li
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Eye tracking studies showed parafoveal previews involved letter transpositions (TL condition) served as better previews than those involved letter substitutions (SL condition), suggesting that English readers could perceive letter position at parafoveal vision. The open bigram theories suggested that the difference of SL condition, TL condition and the identity condition could be explained by open bigram difference in these conditions. Given the open bigram model, letter strings are encoded by activating a series of ordered bigram.

We examined whether character position is encoded in parafovea in Chinese. We embedded two-character words in sentences and manipulated content of parafoveal preview. In the identity condition, the preview word was identical to the target word; in transposed-character condition, two characters in the preview word was transposed from the target word; in substitution condition, two characters of target word were substituted with other two characters. In both experiments, we found reading time was longer in substitution condition than transposed-character condition, which was longer than the identity condition. It suggested that character position was encoded, but not strictly encoded at paraveal vision in Chinese reading. Since there are only two characters in the target word, these results couldn't be explained with the open bigram theories.

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Talks

Models of oculomotor control

Monday, August 12, 14:30 - 15:50

Room: Lilla salen

Chair: Vincent P. Ferrera

Modelling spontaneous fixation durations in infancy: a simulation study with 6 month-olds

Irati Rodriguez Saez de Urabain[1], Antje Nuthmann[2], Mark H. Johnson[1] & Tim J. Smith[1]
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Fixation durations (FD) are well known to be indicators of attention and information processing, but how does control of FD develop during infancy? Can infants adapt their eye movements to different complex viewing conditions? In this study, eleven infants aged 6 months were presented with a set of customized naturalistic and non-naturalistic videos. They performed a gap-overlap task to measure inhibitory control, and a double-step task to investigate saccade cancelations. Results from this study revealed strong positive correlations between disengagement latencies and FD in the naturalistic and non-naturalistic conditions, as well as systematic changes across viewing conditions. We propose a computational model (BabyCRISP, an adaptation of the CRISP model; Nuthmann et al, (2010). Psych. Rev.) that accounts for variability in FD in complex scenes based on mixed control theories of eye movements and the mechanisms underlying saccade programming. The comparison between the empirical data and the model simulations demonstrated how perceptual and cognitive activity can influence infant's FDs and how variations in oculomotor control can be accounted for the parameters of this model. In the future, BabyCRISP will inform our understanding of the development of oculomotor control by enabling individual longitudinal developmental trajectories to be modelled.

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Development of oculomotor control from infants to toddlers: temporal and spatial parameters of reactive saccades

Nadia Alahyane1, Christelle Lemoine[1], Coline Tailhefer[1], Thérèse Collins[2,3], Jacqueline Fagard[2] & Karine Doré-Mazars[1,3]
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The emergence of oculomotor control and its developmental transition from infants to toddlers are still poorly known. Yet, this is a time where eye movements represent a vital means to interact with the surroundings and where the brain undergoes extensive changes. We developed a novel method to investigate real-time control of saccadic eye movements in infants and toddlers. In this paradigm, animated colorful stimuli were presented 10° apart on a screen, at unpredictable locations, over 140 trials. This new approach allowed us to both examine how infants react to sudden visual stimuli and perform fine analysis on saccade characteristics. So far, 70 young participants (6-41 months of age) and 20 adults (20-30 years-old) were recruited. Main results revealed that infants and toddlers showed longer latency and lower saccade accuracy compared to adults, suggesting immaturities in oculomotor control in very young children. Moreover, as expected, latency decreased with age in the child group. An original and exciting finding emerged when looking at participants who performed the whole session: contrary to adults who showed no change in saccade amplitude across trials, infants became more and more accurate. This latter result suggests some underlying process that resembles learning or sensori-motor plasticity.

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Smooth Pursuit Initiation Modulates Response Gain in Visual Cortical Areas MT and MST

Vincent P. Ferrera
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Primates can visually track small moving targets using smooth pursuit eye movements. Target motion for smooth pursuit is computed by neurons in visual cortical areas MT and MST. How visual motion signals are transformed into motor commands for pursuit is not known, but is likely to involve a neural circuit linking MT and MST with frontal cortical areas such as frontal eye field and frontal pursuit area. In this study, we trained monkeys to either initiate or suppress smooth pursuit in the presence of a moving target. We found that the gain of the motor response (eye velocity / target velocity) was nearly zero when monkeys were instructed to suppress pursuit (mean gain = 0.06 ± 0.003) as compared to trials where monkeys were instructed to initiate pursuit (mean gain = 0.8 ± 0.024). We found that neuronal responses in MT and MST to moving targets were 13% weaker on average when monkeys suppressed pursuit vs. when they initiated pursuit (paired t-test, $p < 0.0001$, $n = 68$ neurons). We speculate that neural gain control in MT and MST during the decision to initiate smooth pursuit may be implemented by feedback from frontal cortical areas.

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A basal ganglia model for robotic eye movement control

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In the oculomotor system there are different sub-systems that are in competition for a common resource, the eye muscles. These functional units are physically separated within the brain but are in competition for behavioural expression. The principle of parallel but distinct pathways for pursuit and saccades extends to circuits involving the basal ganglia and the thalamus. Several studies have shown how tonic inhibition, exerted on the Superior Colliculus (SC) through this pathway, is involved in regulating the triggering of saccades. Recently, it has been demonstrated that the caudate receives input from the part of Frontal Eye Field (FEF) involved in smooth pursuit tasks. Thus, there is a partial overlap in the brain stem pathways for pursuit and saccades. In this work, a possible model of the gating system regulated by basal ganglia, which endows these evidences, has been simulated and implemented in the iCub robotic platform. Experimental results show how this structure can regulate the action selection respect to the kind of the stimulus provided. The basal ganglia model shows important features like the clear suppression of the non-selected competitor, allowing persistence of the selected action. This in turn, helps to better understand of the dynamics of the oculomotor control.

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Talks

Educational psychology I

Monday, August 12, 14:30 - 15:50

Room: Sångsalen

Chair: Tamara van Gog

Students' strategy use in understanding biological process diagrams

Marco Kragten[1], Wilfried Admiraal[2] & Gert Rijlaarsdam[1]
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To evaluate which strategies students use and which of these are effective in understanding biological process diagrams, we conducted two studies and an experiment. In Study 1, students were provided with a learning task when presented a process diagram. After the learning phase the students were shown an animation of their gazes and were instructed to retrospectively think aloud. Expected results are that student's strategy use varied. In Study 2, the students were presented another diagram and after the learning phase the quality of their constructed mental model was measured. Expected results are that the level of structuredness of the strategy predicts the quality of the constructed mental model and that students' strategy use was consistent throughout Study 1 and 2. In the experiment, we tested the effect of a simple instruction on strategy use while solving a problem related to a process diagram. Expected results are that the simple instruction influenced students strategy use and improved their performance on problem solving. The simple instruction is also expected to have a positive effect on the experienced cognitive load.

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Using eye tracking to map Brazilian students online navigation in a learning process

Eduardo Santos Junqueira, Romulo Barbosa Monteiro & Elisangela Teixeira
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This study uses a Tobii T120 to map students' online navigation as they read, interact and write during their study time at the computer. Participants are enrolled in Mathematics and Brazilian Arts and Letters blended teacher preparation degree at a federal university in Brazil. Pre-tests were conducted in the lab to document four students' saccades, i.e. their eye movements on the screen, including jumps, fixations, regressions and advancements. Results of data analysis indicated non-linear, non-sequential navigation as they study online. Based on Santaella's typology it was identified the occurrence of the provident navigator type, which executed routines and demonstrated knowledge about how to navigate, and the expert navigator, who executed a fast-paced and to the target navigation. A third new type emerged as students demonstrated a lack of familiarity with the navigation, but they seemed to adapt to it as they demonstrated knowledge on how to use available tools to find information. Page structure was not significant in directing their navigation as they tended to ignore links and images on the screen. Although students were acquainted with the LMS and internet searching tools, they struggled to direct their online searches towards top quality materials, indicating low digital literacies.

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Children's visual attention to Internet adverts depends on individual level of oculomotor control

Nils Holmberg[1], Kenneth Holmqvist[2] & Helena Sandberg[1]
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26 Swedish children in 3rd grade were observed while surfing on their preferred Internet websites for a limited period of time. We recorded eye movement data from the participants, as well as synchronized real-time screen recordings of all the dynamic web stimuli that the children interacted with on-screen. Afterwards, the web stimuli were analyzed in order to quantify low-level saliency information in the Internet adverts, as measured by changes in motion, luminance and edge information over time. The eye movements of the children were then calculated in relation to the web stimuli, and encoded as a binomial dependent variable, describing whether a particular advert had been looked at. A mixed-effects multiple regression analysis was performed in order to test the relation between visual saliency in Internet adverts and the location of the participants' visual attention. The regression model also included individual level of oculomotor control and weekly amount of Internet use as predictors of visual attention to adverts. Results from the analysis show that all measures of visual saliency had an effect on children's visual attention, but that the strength of this effect varies between saliency measures, as well as with individual level of oculomotor control.

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Teachers' Visual Expertise: Differences between expert and novice teachers' viewing of dynamic classroom scenes

Charlotte E. Wolff, Halszka Jarodzka & Henny P.A. Boshuizen
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While visual expertise in various professional domains has been extensively explored, the visual expertise of teachers has received little attention. In this study we addressed this gap by showing dynamic stimuli from the visually complex context of classroom teaching to 67 teachers, of which 35 were experienced secondary school teachers and 32 were first and second year teachers-in-training. We recorded participants' eye movements with an SMI RED 250 Hz as they viewed video fragments showing authentic lessons delivered by beginner teachers. Three types of videos were used, which displayed different types of classroom management events. Type A videos showed multiple, unrelated events; Type B videos showed multiple, inter-related events; and Type C videos showed multiple, inter-related events with one striking classroom management event. Repeated measures analysis of all three video types yielded significant expertise-based effects; novices' eye movements were more dispersed whereas experts' were more focused. That is, irrespective of how the scenes were constituted, experts were able to focus their attention on specific, relevant areas, while novices' attention was scattered around the classroom. These findings represent initial steps towards a deeper understanding of teachers' visual expertise, differences between beginners and experienced teachers, and the analysis of dynamic classroom stimuli.

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Talks

Reading in dyslexia

Monday, August 12, 16:10 - 17:30

Room: Stora salen

Chair: Manon Wyn Jones

What automaticity deficit? Dyslexic readers' activation of lexical information in a RAN-Stroop task

Manon Jones[1] & Kristina Moll[2]
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Reading fluency is often indexed by Rapid Automatized Naming speed (RAN), which measures the automaticity with which familiar stimuli (e.g., letters) can be retrieved and named. Dyslexic readers are thought to be less automatized in lexical retrieval, reflected in consistently slower RAN times compared with non-dyslexics. We compared the automaticity with which adult dyslexic and non-dyslexic readers activated lexical representations in a novel RAN-Stroop task. In a 10 x 4 array of letters, specific letter fonts changed colour from from black to (e.g.) green (upon fixation). The participant was required to rapidly switch from naming the letter to naming the letter colour. In line with Stroop logic, slower colour naming reflects interference from automatic, bottom-up lexical processing. If dyslexics' slower RAN times reflect less automatized lexical retrieval, we would expect less of a Stroop effect on dyslexic naming times compared with non-dyslexics. In fact, we found the opposite pattern: The Stroop manipulation further increased dyslexic eye-voice spans, which increased further still when the letter's orthographic or phonological features were primed. These surprising findings suggest that dyslexics do not have an automaticity problem in RAN. Slower RAN may instead reflect post-lexical decision processes in identifying correct representation(s).

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Mindless Reading to Examine Non-Linguistic Processing During Reading in Children with Dyslexia

Thomas Günther[1], Christina Kraatz[1], Wolfgang Scharke[1], Jennifer Cröll[1] & Ralph Radach[2]

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Mindless reading, e.g. the Landolt task (LT), is a methodology to examine non-linguistic processing demands of reading (Radach, Günther, & Huestegge, 2012). The aim of this study was to examine the performance of children with dyslexia on a well examined mindless-reading paradigm in more detail. A total of 50 children from 3rd and 4th grade participated in the study, 26 children with dyslexia (CWD) and 24 normal reading controls (NRC). All children read 36 age-appropriate sentences in the first condition (sentence reading) and the same sentences in a second condition, wherein each letter was replaced by a Landolt ring with the same size (Landolt reading). As expected, CWD were impaired on the reading task on spatial and temporal measurements of the eye movements. The two groups also differ on the LT. Post-hoc analyses showed that 12 of the CWD had significant higher viewing times and a higher deviation of the preferred initial landing positions in both tasks. The preliminary results of the study indicate that impaired non-linguistic processes could influence the reading performance in a subgroup of CWD. It is hypothesized that attentional and/or visuo-spatial problems could be an explanation for the limited results on the Landolt paradigm.

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Predicting Reading Disability from Eye Movements

Mattias Nilsson
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The earlier reading disability is detected in school children, the better the effect of supportive intervention. We propose machine learning of eye movements during reading as an objective, efficient and accurate method for detecting reading problems in an individual child, relative to expectations of what is typical for the age and grade level. Based on eye-movement recordings of 103 third-grade children with reading disabilities (RD) and 90 children with normal reading capacity (NR), we train classification models that learn to predict the status (RD or NR) of any third-grade child, given his or her eye-tracking record. We evaluate a number of inference models and show that a multilayer perceptron neural network predicts the status of a child outside the training set with an accuracy of 94%. We also investigate how classification accuracy depends on recording time and show that nine-in-ten are correctly classified after only 30 seconds of tracking time. Although eye movements that deviate from normal are symptomatic of reading problems rather than causal, this study demonstrates that eye movements are highly useful for early identification of language-related deficiencies. Considering the high diagnostic performance and fast assessment, the method has potential use in screening school-age children for reading deficits.

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Atypical landing positions suggest differential sensitivity to orthographic information in the parafovea for dyslexic readers

Julie A. Kirkby
Bournemouth University, United Kingdom

Patterns of eye-movements were studied in 15 dyslexic and 14 age and IQ-matched controls during reading. Standard reading batteries demonstrated a marked deficit in word reading and RAN speed for dyslexics compared to controls. Word frequency was manipulated in two experiments: an experimental paradigm derived from the lexical decision task (words vs. non-words), to elicit optimal viewing positions (OVPs) from readers, and continuous reading, to obtain preferred viewing locations (PVLs) from readers. Robust frequency effects were obtained in both experiments; however, dyslexic readers were consistently poorer than controls at word and sentence reading. Also, typical OVP effects were found for both groups (i.e. response times were shortest when fixations were located slightly left of the center of the word). During continuous reading, however, while typical readers' initial landing positions were not influenced by the frequency of the target word, dyslexics' initial landing positions were shifted .25 characters to the left in high frequency words, and .5 characters left in low frequency words relative to that of skilled readers. Landing position profiles during continuous reading suggest differential sensitivity to orthographic information and atypical saccadic targeting for dyslexic readers compared with typical readers.

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Talks

Methods I

Monday, August 12, 16:10 - 17:30

Room: Nya fest

Chair: Arantxa Villanueva

Robust Gaze Estimation in Low-Resolution Eye Images

Axel Schroth[1], Sascha Voth[2] & Tobias Schuchert[2]
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A Head Mounted Display (HMD) with a bidirectional chip is an emerging technology with many applications enabling us to display information to users while simultaneously analyzing eye movement. However, due to the high density of light emitting and capturing elements, the eye image suffers from noise artefacts and low-resolution output. Two topics are addressed by this work: low resolution eye tracking and comfortable calibration.

Robust eye tracking includes detection of corneal reflections, classification of closed eyes and pupil extraction. Therefore, several different approaches are compared, an extended approach presented and evaluated. Robustness of the proposed approach is increased by incorporating temporal information. A final evaluation shows that implemented extensions improve accuracy significantly.

A calibration process is required to estimate gaze points of a user. The second part of this work is about evaluating different ways of calibration methods and presenting novel methods which are more comfortable. The standard multiple point calibration procedure is amended by using automatic methods and animated objects. Finally an implicit calibration by reading text is presented, which makes the disturbing calibration procedure almost invisible to the user with only slight degradation of accuracy.

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Focal length effect in gaze estimation algorithms

Laura Sesma-Sanchez, Arantxa Villanueva & Rafael Cabeza
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Today, commercial web cams provide images with resolutions comparable to the ones obtained with the usual industrial cameras employed in high performance eye trackers. However, web cam based eye tracking has other difficulties to solve such as a wider field of view and a lower image quality. Although web cams are improving their quality in terms of resolution and ambient light tolerance in a very fast way, usually their lenses are of a lower quality and the focal length is smaller than the one in commercial gaze tracking systems. The aim of this work is to calculate the impact of the focal length in the accuracy and precision of gaze estimation methods that are widely used in commercial systems and well known by researchers working in the field, such as interpolation and geometrical methods. Two methods have been analyzed in a simulated environment, for a camera resolution of 1600x1200 pixels for focal lengths from 36 down to 4mm. The results show that the two methods tested suffer from the focal length effect and the estimation error increases significantly as the focal length decreases.

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A calibration method for independent eye and scene cameras in a gaze tracking system

Huageng Chi, Kristian Lukander & Sharman Jagadeesan
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We have developed a novel, wearable and robust model-based method for tracking gaze in a free use environment. The system employs an infrared eye camera, and a scene camera. A 3D eye model is used for estimating the gaze vector with respect to the eye camera coordinate system. For gaze point tracking, this gaze vector needs to be mapped to the scene camera coordinate system. A key step here is to determine the spatial relationship between the two cameras, who do not share even a partial view, so standard two-camera calibration procedures do not apply.

We developed a calibration method, using a calibration rig with two simple calibration patterns at each end of the rig. As the geometry of the rig, and thus the relationship between the patterns is known, we can calibrate the transformation between the coordinate systems of the two cameras.

We verified the method by simulating calibration in an OpenGL rendered environment. A convenient C++ QT GUI application was developed for the two camera calibration. Future work includes moving to binocular eye cameras (three camera system) to enable gaze point depth estimation, as well as developing methods for two camera calibration eliminating the use of a rig.

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EagleEyes: Using Eye Movements to Enable People with Profound Disabilities to Express their Humanity

James Gips
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For almost 20 years EagleEyes has enabled children and young adults with the most profound physical disabilities to use eye control to express their humanity. EagleEyes tracks gaze only approximately but does allow a person to control the mouse pointer on the screen just by eye movements. EagleEyes works through five electrodes placed on the user's head. Over 150 EagleEyes systems have been distributed. In 2013 we hope to distribute another 50 systems. EagleEyes is intended for children and young adults who have no voluntary control of arms, legs or head and who cannot speak, people who are locked in, but who can move their eyes. These are children and young adults whose very mental and cognitive functioning is in doubt by many, who may not follow directions or requests, and who may not understand initially that their eye movements are causing the mouse pointer to move. In many cases EagleEyes has been critical in allowing them to show their humanity.

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An investigation into modelling the components of gaze gesture performance

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Currently, most investigations of gaze gesture performance quote a measure of time to complete the total gesture as the major metric of performance. It is often unclear whether this includes the fixation that precedes the sequence of eye movements, the fixation that concludes the movement or both. In this study we have investigated how different gesture patterns are composed in terms of saccades and fixations. Some gestures can be characterised as minimal gestures in that one and only fixation is needed to signal each 'leg' of the pattern. Others we can describe as 'minimal plus one' in that each leg of the gesture pattern is completed with two fixations. Together these fixations and intermediate saccades account for a large proportion of time a gesture takes to make. We have also studied the impact on the outcomes of different minimum durations and dispersions used to define the actual fixations. We propose to model gesture performance by adding time components associated with saccades and fixations. This is very similar to the approach that Card, Moran and Newell's Keystroke Level Model used in the 1980's to estimate task performance involving task entry using keyboard and mouse.

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Talks

Memory

Monday, August 12, 16:10 - 17:30

Room: Lilla salen

Chair: Werner Schneider

Image Memorability in the Eye of the Beholder: Evidence from Pupil Dilations and Fixation Distributions

Melissa Le-Hoa Vo[1], Zoya Gavrilov[2] & Aude Oliva[2]
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Why do some images stick to our mind, while others seem to be forgotten only moments after first seeing them (Isola et al., 2011)? In this study, we tested whether differences in image memorability 1) are stable over time, 2) show differential fixation distributions, and 3) are mirrored by graded pupillary responses. We tracked participants' eye movements and pupillary responses while they viewed a sequence of < 1200 images for 2sec each with the instruction to press a key whenever they noticed an image repeat. Differences in memorability were already clearly visible at the shortest lag (20sec) and became more pronounced as time passed on ($\sim$11min). We further found that pupils dilated significantly more for hits than correct rejections. This "pupil old/new effect" (Võ et al., 2008) increased with decreasing image memorability. Finally, successful memory retrieval coincided with a higher degree of fixation distribution overlap between encoding and retrieval. This effect was strongest for high memorability images, but almost disappeared for low memorability images. Together, these data suggest that during memory retrieval inherent semantic and visual image features not only pose differential degrees of cognitive load on an observer, but also determine what parts of an image are preferentially processed.

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Automatic encoding of the saccade target into visual working memory

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Visual attention plays an important role in encoding objects into visual working memory (VWM). According to one view, VWM and attention reflect the same selective mechanism. Therefore, covertly attending an object should be equivalent to its encoding into VWM. Alternatively, encoding of an attended object into VWM may be obligatory only when the shift of attention occurs before a saccade; only when a saccade is executed is memory required to bridge the perceptual disruption. Two studies investigated whether attended objects are automatically encoded into VWM as a function of whether the object was or was not the target of saccade. Participants either overtly or covertly attended to a task-irrelevant object. Encoding into VWM was assessed by 1) the extent to which the attended object interfered with a concurrent VWM task and 2) the degree of capture generated when the object's features were associated with a distractor during subsequent visual search. In both cases, attended objects were encoded into VWM only when the object was the target of a saccade; covert attention alone was not sufficient for VWM encoding. These results support the view that perceptual gaps created by saccades necessitate automatic encoding of the saccade target item into VWM.

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The role of eye movements for spatial serial recall

Elke B. Lange, Ralf Engbert & Sebastian Henschke
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The role of eye movements for spatial attention has been demonstrated in a broad range of studies, whereas its role for spatial memory is less clear. On the one hand, spatial attention precedes saccades to the target location. Memory for spatial locations might benefit from both, representations of attended locations and saccadic information of the relations between attended information. On the other hand, due to the retinotopic organization of the visual cortex, moving the eyes might cause interference with establishing a reliable allocentric spatial representation. In two eye-movement studies (Lange & Engbert, QJEP, in press) we compared eye-movement control for verbal and spatial encoding, demonstrating remarkable differences: Whereas verbal encoding was characterized by making precise saccades to the stimuli, saccadic activity was depressed during spatial encoding, demonstrated by the reduced probability to fixate an item, increased saccadic reaction times, and smaller saccadic amplitudes. Memory performance between tasks did not differ, indicating that encoding strategies were optimized for task requirements in a free viewing condition. However, when viewing strategies were forced onto the participants, tracing the stimuli as well as fixating centrally on the screen resulted in dual-task costs. Hence, optimized encoding strategies work on an involuntary level only.

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To see or not to see: natural viewing conditions play a beneficial role in memory consolidation of saccadic adaptation

Caroline Voges, Christoph Helmchen & Andreas Sprenger
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Saccadic adaptation is a widely used paradigm to study motor learning and memory. Adapted gain of reactive saccades is still detectable even months after adaptation as long as it is tested in the same context. However, it shows some decrease over time. The influence of visual input on this consolidation is still unclear.

In our study the role of visual input during wakefulness and sleep on consolidation and relearning of adapted gain was investigated in healthy subjects. Therefore, we analyzed learning curves before and after different visual conditions following adaptation: (i) unrestricted viewing over two hours and visual deprivation by (ii) Ganzfeld stimulation (GS) or (iii) eye closure during sleep. GS provides visual deprivation from fixation cues by a uniformly illuminative stimulation. Our results indicate a significantly better motor memory consolidation during normal viewing compared to GS or one night of sleep: the first saccade after consolidation following unrestricted viewing showed a retention of 74

We conclude that spatial constancy during normal viewing is beneficial for consolidation of adapted saccadic gain compared to visual deprivation of light (sleep) and fixation targets (GS).

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Eye fixations and face recognition: It is recollection that rises from first to second fixation, not familiarity

Charlotte Schwedes & Dirk Wentura
Saarland University, Germany

It is known that recognition performance for faces rises from the first to the second fixation on a face and that further fixations do not improve recognition performance (see Hsiao & Cottrell, 2008). This finding persisted, when the confoundation between the presentation duration of a face and the number of allowed fixations to a face was removed. However, what is responsible for the improvement is not yet clear. Based on tentative findings by Schwedes and Wentura (2012) we derived the hypothesis that the improvement from the first to the second fixation in the recognition performance is mainly due to a boost of recollection. To test this, participants (Exp. 1: N= 29; Exp. 2: N = 38) familiarized themselves with a set of faces in the learning phase. In the following recognition test, faces were presented trialwise in random order for either one or two fixations (controlled by an eye-tracking device) followed by a remember/know/guess procedure. The results show better recognition performance when participants were allowed to make two fixations (thereby replicating Hsiao & Cottrell, 2008). Most important, this improvement is mainly due to a rise in recollection.

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Talks

Special symposium on visual expertise in medicine

Monday, August 12, 16:10 - 17:50

Room: Sångsalen

Chair: Halszka Jarodzka

Investigating the diagnostic process of medical images with eye tracking

Helen Jossberger, Tristan Haselhuhn & Hans Gruber
University of Regensburg, Germany

Experts are able to process domain-specific information fast and more accurate than less skilled subjects. This is based on differences even in the perception of stimuli. Experts encode meaningful patterns rather than isolated items, and thus they are able to process information differently. This study analysed the nature of expertise in the domain of radiology. We compared a total of 40 subjects of four different levels of expertise while scanning CT slice images: controls, novices, semi-experts, and experts. Eye-tracking technology was used to analyse subjects' visual information processes. The subjects had to study authentic CT slice images of three levels of difficulty and to decide whether a pathological finding was present. The following parameters were measured: duration of fixations, dwell time in relevant areas, time until first fixation in relevant area, hit rate, duration of inspection of images. In addition, an expert radiologist rated the correctness and elaboration of the diagnoses. We found that experts outperformed the other groups significantly: the number of correctly diagnosed CT images increased with growing expertise and experts were more specific in their elaborations. Experts diagnosed the images faster than the other groups. Moreover, expertise-related differences in the eye-movements were found.

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Systematic viewing in Radiology

Ellen Kok[1], Halszka Jarodzka[2], Anique de Bruin[1], Simon Robben[3] & Jeroen van Merriënboer[1]
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[3]Maastricht University Medical Centre

Radiologists advocate 'systematic viewing' as a way to avoid missing abnormalities while diagnosing chest x-rays. Systematic viewing refers to keeping to a fixed order of inspecting anatomical areas and is thought to ensure that the entire image is inspected. We investigated this using two ways of defining AOIs: based on anatomical regions (semantic) and using a grid (spatial). We compared these two AOI approaches to address the following questions. (1) Is systematic viewing related with coverage of the image and by that, with performance? (2) Do both systematic viewing and coverage increase with expertise? (3) To what extend are participants able to draw their own viewing behavior? Five conventional chest radiographs were inspected by eleven medical students, ten residents and nine radiologists while their eye-movements were recorded. Afterwards they drew where on the image they had looked. Regardless of AOI approach, we found no relationship between systematic viewing, coverage and performance. Radiologists viewed the images more systematically, but covered less of the image compared to students. Participants were not very well able to draw their own viewing behavior, although differences between eye-movements and drawings depended on type of AOI analysis and expertise.

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Expertise Development under the Microscope

Thomas Jaarsma[1], Halszka Jarodzka[1], Marius Nap[2], Jeroen J.G. Van Merriënboer[3] & Henny P.A. Boshuizen[1]
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Visual expertise is of crucial importance for clinical pathologists. However, the pedagogy of resident training in pathology relies mostly on diagnosing as many cases as possible. In this study, eye tracking, verbal protocols, and performance data are used to investigate the characteristics of expertise levels and the differences between them. These findings should contribute to improving current training methods.

Pathologists (13), residents (12) and medical students (13) diagnosed 10 static, coloured microscopic images with 2 seconds of viewing time. They verbally explained their diagnosis afterwards. Eye movements were analysed as basic parameters and as AOIs on diagnostically relevant areas. Furthermore, we analysed trial halfs separately to investigate changes in the viewing process. Verbal data were analyzed by protocol analysis.

Results show that novices fixate less in AOIs, often diagnose incorrectly, and are vague and incorrect in their explanations. Diagnostic performance of intermediates and experts is similar, but they have different viewing behaviour. Fixation dispersion of intermediates in the second trial part decreases, whereas for experts it increases. Intermediates thus seem to check, experts explore. Verbally, experts display more judging abilities.

These characteristics for the expertise levels in clinical pathology could be addressed specifically to improve education.

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The effect of expertise on eye movement patterns in medical image perception

Raymond Bertram, Laura Helle, Johanna Kaakinen & Erkki Svedström
University of Turku, Finland

The current eye movement study assessed the effect of expertise on eye movement behavior during image perception in the medical domain. Radiologists, CT radiographers, and psychology students were exposed to 9 volumes of multi-slice stack-view CT images from the upper to the lower part of the abdomen with or without any abnormality. The images were presented in succession with low, medium or high speed, while the participants had to detect enlarged lymph nodes or other - visually more salient - abnormalities. As expected, the radiologists outperformed the other groups in detection of enlarged lymph nodes. In general, they used saccades of shorter amplitude than the other two participant groups. Moreover, unlike the other groups they reverted to more fixations on relevant areas and used fixations of longer duration when enlarged lymph nodes were present in the images. Other abnormalities were detected equally well by radiologists and radiographers, both groups outperforming psychology students. However, radiologists needed fewer fixations to decide upon the presence of these abnormalities. On the basis of these results we argue that the level of expertise is manifested in distinct eye movement patterns of proactivity, reactivity, and suppression, depending on the nature of the stimulus or materials.

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Talks

Saccadic programming I

Tuesday, August 13, 10:20 - 12:00

Room: Stora salen

Chair: Zoi Kapoula

Unilateral deactivation of dorsolateral prefrontal cortex biases saccade target selection

Kevin Johnston, Stephen G. Lomber & Stefan Everling
University of Western Ontario, Canada

The ability to select and generate saccades toward visual targets depends upon an interconnected network of brain areas. In frontal cortex, the contribution of the frontal (FEF) and supplementary (SEF) eye fields has been investigated extensively, but the contribution of the dorsolateral prefrontal cortex (dlPFC) has been relatively neglected. To address this, we used the cryoloop technique to reversibly deactivate the cortex lining the banks of the caudal portion of the principal sulcus, a subregion of the dlPFC, in rhesus macaque monkeys performing a free-choice saccade task. In this task, single visual targets were presented sequentially in the left and right visual fields at various stimulus onset asynchronies, and the animals were rewarded for generating a saccade to either stimulus. Unilateral dlPFC deactivation biased monkeys' behaviour such that the proportion of saccades toward stimuli in the visual field contralateral to the deactivated hemisphere was reduced, and decreased reaction times of saccades to stimuli in the visual field ipsilateral to the deactivated hemisphere. These findings suggest that the dlPFC plays a role in the process of saccade target selection, possibly by sending bias signals to other cortical and subcortical nodes of the saccade network.

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Saccadic amplitude shapes adaptation transfer profile

Svenja Gremmler & Markus Lappe
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Saccadic adaptation is the ongoing motor learning process that keeps saccades ending accurately on their targets. It is eye position specific and the transfer of adaptation from one starting position to other starting positions was found to be linear in human subjects. If larger amplitudes are employed, macaques in contrast show a Gaussian shaped transfer profile of saccadic adaptation. We investigated the influence of the size of the saccadic amplitude during adaptation on the shape of the transfer profile in human subjects. Adaptation of a large saccade of 20 deg amplitude transferred incompletely to two neighboring starting positions, denoting a peaked transfer profile. After we adapted a saccade of 7 deg amplitude the transfer to the more central starting position was incomplete whereas the adaptation state of the saccade started at the second start position was even higher than the adaptation state at the trained position. These findings are consistent with a linear transfer profile of adaptation. We assume that the adaptation mechanism depends on the reference frame in which the eye movement is encoded and that the choice of the reference frame is determined by the size of the saccadic amplitude.

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Visuo-oculomotor abilities of a single hemisphere: a study of bilateral saccadic eye movement 'corollary discharges' in hemidecorticate subjects

Kate Rath-Wilson & Daniel Guitton
McGill University, Montreal Neurological Institute

The study of hemidecorticate patients has allowed us to discover that a single hemisphere is capable of many oculomotor abilities believed before to require the integritiy of both hemispheres, including the generation of accurate bilateral saccades and the monitoring of bilateral smooth pursuit using a corollary discharge (CD) signal (Herter and Guitton, 2004). Literature suggests that lesions of parietal areas cause marked deficiencies in saccadic eye movement monitoring contralesionally. In the present study, we sought to determine whether the hemidecorticate brain is capable of monitoring saccadic eye movements bilaterally. Using a novel version of the double-step task, we have shown that a single hemisphere can monitor bilateral eye movements, and integrate this information into subsequent targeting saccades in the dark. While their performance is markedly worse than controls – mainly due to their 'need' to maintain a target in their seeing hemifield – they are surprisingly more capable than subjects with isolated unilateral parietal lesions performing similar tasks. These findings suggest that further research into the relationship between performance and the extent of the cortical lesion should be conducted; it is possible that larger cortical lesions permit greater plasticity in remaining brain areas, an idea that could have profound clinical implications.

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Saccadic adaptation may involve multiple reference frame in parallel

Laure Pisella, Delphine Levy-Bencheton, Muriel Panouillières, Caroline Tilikete & Denis Pélisson
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Saccadic adaptation is usually considered oculocentric: adaptation of rightward saccades does not transfer to leftward saccades. However, Zimmermann et al. (2011) showed that outward adaptation of rightward scanning saccades transferred to memory-guided double-saccades aiming the same visual target, independently on their direction (as if the visual target was re-localized). The authors proposed that this adaptation occured in spatiotopic coordinates but mentioned that their subjects may have used the frame of the computer screen as an allocentric reference frame. In the present study, nine subjects performed the same adaptation paradigm as in Zimmermann et al. (2011) with and without a visible frame. The amplitude of leftward memory-guided double-saccades changed after adaptation but only when a frame was provided in agreement with the allocentric hypothesis. However, the remapping processes involved in double-saccades may have favored allocentric coordinates. Indeed, leftward single memory-guided saccades were modified by the same adaptation paradigm, even in absence of visible frame, in agreement with spatiotopic adaptation. In a last experiment, we show that the same adaptation does not transfer to leftward visually-guided single-saccades, a sign of oculocentric adaptation. Taken together, these three experiments indicate that the same saccadic adaptation can involve allocentric, spatiotopic and oculocentric coordinates.

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Short-term repetition effects of saccade-vergence eye movements

Zoi Kapoula, Alexandre Lang, Chrystal Gaertner, Elham Ghassemi & Qing Yang
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Combined eye movements in direction (saccade) and in depth (vergence) are the most frequent in everyday life. Deficits of vergence are frequent. Clinical rehabilitation is based on repetition of vergence. The purpose of this study was to examine short-term repetition effects on the trajectory of combined eye movements. Fourteen healthy subjects performed 80 convergent and divergent combined movements during 5-minutes periods. Gap and overlap tasks were used to promote automatic and controlled triggering respectively. The results showed that in the gap task only convergent movements were modified: the latency of the two components increased and their amplitude and mean speed decreased. This indicates a fatigue effect that is specific to convergent movements. In the overlap task, the amplitude of convergent movements for both components as well as the mean speed of the saccade component increased with trials. In contrast, the mean speed decreased and the duration increased for divergent movements. Thus, short-term repetition effects are different for convergent and divergent movements, and depend on the mode of triggering (gap vs. overlap). This has consequences for rehabilitation purpose. At the theoretical level, these data are compatible with the idea that divergence and convergence during combined movements are supplied by different systems.

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Talks

Special symposium in Honour of Rudolf Groner, part 1

Tuesday, August 13, 10:20 - 12:00

Room: Nya fest

Chairs: Eva Siegenthaler, Walter Bischof

The effect of internally generated eye blinks on the preview benefit in visual marking

Adrian von Muhlenen, Derrick Watson & Daniel O. A. Gunnell
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The preview effect in visual search describes how people can ignore old (previewed) stimuli in order to prioritize the processing of newly appearing stimuli (Watson & Humphreys, 1997). According to the inhibitory visual marking account, this is achieved by the top-down and capacity limited inhibition of old stimuli already in the field, which leads to a selection advantage for new items when they appear. In contrast, according to the abrupt luminance onset account, new items capture attention automatically simply because they generate luminance onset signals. The first Experiment shows that a robust preview benefit occurs even when stimuli are presented during an eye blink. This result ocurs regardless of whether or not the old and the new items differ in their color (Experiment 2). However, 'artificial blinks', generated by turning the display off and on cause the preview benefit to be totally abolished (Experiment 3 and 4). Overall the findings suggest that both luminance onsets and inhibition of the old items play important roles in the prioritization of new visual information. Further they show that internally generated disruptions to a scene caused by eye blinks do not lead to a destruction of inhibitory representations suppressing old items from future selection.

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Eye-head coordination abnormalities in schizophrenia

Simon Schwab[1,2], Othmar Würmle[1], Nadja Razavi[1], René M. Müri[3] & Andreas Altorfer[1]

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Eye-movement abnormalities in schizophrenia are a well-established finding. In such studies, visual targets are usually presented in the center of the visual field, and the subject's head remains fixed. However, in every-day life, targets often appear in the periphery and the head is moved. This study is among the first to investigate eye-head coordination in schizophrenia by presenting targets in the periphery. Two different visual recognition tasks, color recognition and Landolt orientation tasks, were presented. Eye and head movements were simultaneously recorded using video-based oculography and magnetic motion tracking of the head. The patients (n=14) had similar saccadic latencies in both tasks, whereas controls (n=14) had shorter saccadic latencies in the more difficult Landolt task. Patients performed more head movements, and had increased eye-head offsets. We conclude that patients with schizophrenia may not be able to adapt to the two different tasks to the same extent as controls, supporting the hypothesis that schizophrenia patients have difficulties determining the relevance of stimuli. Patients' uneconomic over-performance of head-movements may possibly be caused by alterations in frontal executive function that impair the inhibition of head shifts.

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New Eye Movement Measures in Human Factors Research

Eva Siegenthaler[1,2,3], Francisco M. Costela[1], Jorge Otero-Millan[1], Michael B. McCamy[1], Leandro Di Stasi[1], Stephen L. Macknik[1] & Susana Martinez-Conde[1]

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Eye tracking is used commonly in human factors research in connection with human mental workload measurements (e.g. in the context of air-traffic control training to reduce errors, or in the healthcare field to improve doctors' performance in medical procedures). Current eye movement measurements in human factors research include fixations (e.g. fixation duration, number of fixation), saccades (e.g. number of saccades, saccade amplitude) and related metrics (e.g. gaze and scanpath measurements), but their relative importance remains controversial. In addition, recent studies have used fixational eye movement dynamics (microsaccades, saccadic intrusions) as a novel indicator of mental workload (Benedetto, Pedrotti & Bridgeman, 2011; Tokuda, 2011). We will present results that show a relationship between fixational eye movements and mental workload during mental arithmetic.

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Very High Resolution Eye Movement Recording System

Kazuo Koga
Kyoto Notre Dame University, Japan

I describe a custom-made Purkinje corneal reflection autotracking system, which consists of a video XY tracking component and an optical magnification system. The system has a temporal resolution of 60 Hz and a spatial resolution of 2.4 – 4.2 arc min over a horizontal and vertical measurement range of 10.2 – 17.9 arc deg. The high spatial resolution of the tracker opens new possibilities for investigating ocular mechanisms. In a first application, I performed a nystagmus analysis. An FFT analysis revealed two dominant components at about 1 Hz and 8 Hz, the former synchronized with cardiac activity. I will discuss the implications of these results for applications where precise fixation is important, e.g. for military snipers. In a second application, I studied the ocular response of infants viewing simple line drawings in a psychophysical paradigm. Thanks to the autotracking capabilities of the system, I was able to produce the spatial distribution of saccades and fixations from the Peristimulus Time Histograms (PSTH). This method opens up new possibilities for studying infant psychophysics without the need for restricting body movements and without reliance on verbal responses.

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Eye movements in the domestic horse (Equus caballus)

Iain D. Gilchrist[1], Julian C. Partridge[2] & Jeremy F. Burn[3]
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[3]Department of Mechanical Engineering, University of Bristol, UK

Horses have laterally positioned eyes with a wide horizontal field of view (about 200 degrees). Spatial acuity across the field varies with highest acuity along a horizontal retinal strip. Horses are active both day and night, and generate a large range of head movements during both grazing and locomotion.

We have built what we believe to be the first fully mobile eye tracking device for horses. The head mounted system uses two infra-red cameras to record the eyes and three visible spectrum cameras to capture the surrounding scene.

Horse eye movements are primarily characterised by large rotations about the primary axis. This is in contrast to other animal where active sampling (such a saccades and fixations) dominates.

We will contrast this ocular-motor strategy with other animals (including humans) and will argue that this strategy reflects the primary functions of vision in horses: to monitor the environment for predators and support locomotion, largely in open habitat and across a wide range of ambient lighting levels. This need has resulted in a visual system in which vision is enhanced around the horizon and the eyes move to maximize visual acuity by stabilizing the image on the retina.

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Talks

Reading development

Tuesday, August 13, 10:20 - 12:00

Room: Lilla salen

Chair: Ralph Radach

Eye movements and comprehension monitoring skills in developing readers

Ralph Radach[1], Christian Vorstius[1] & Christopher Lonigan[2]
[1]University of Wuppertal, Germany
[2]Florida State University, USA

We report results of a series of eye movement experiments on skills and strategies used by elementary school students during reading for comprehension. Targeting a basic level of automated comprehension skills we studied the processing of verb-object relations within or across event descriptions. Strategies used to acquire information related to the main topic of a passage were examined as a core component of higher-level comprehension monitoring.

Differences in gaze duration and total reading time provide evidence for substantial sensitivity with regard to the typicality of concepts serving as objects, actors or instruments within a currently developing event representation. At the same time there appeared to be very little priming of verb-agent relations across consecutive events. More skilled readers utilized long range regressive saccades in spatially selective repair operations when semantic inconsistencies were detected.

On the level of paragraph reading, individual differences in eye movement patterns revealed the development of strategies employed by successful vs. struggling readers to maintain coherence and to overcome comprehension difficulties. A major source of variability in this process turned out to be the efficiency with which students are able to locate relevant information, pointing to spatial memory as a major determinant of success in comprehension monitoring.

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Eye movements in developing readers: A comparison of silent and oral reading

Christian Vorstius[1], Ralph Radach[1] & Christopher J. Lonigan[2]
[1]University of Wuppertal, Germany
[2]Florida State University / Florida Center for Reading Research

Our understanding of reading development both from an information processing and visuomotor control perspective is still quite limited. Findings reported here represent year-1 results from a standard sentence reading task as part of a large cross-sectional and longitudinal study including over 500 readers from grades 1 to 5. Sets of sentences with embedded target words were read silently and aloud for comprehension.

As expected, results show a steady gain in reading speed from 1st -5th grade, evident in decreased times on all word viewing duration measures. Contrary to typical findings with adults, gaze durations and total reading times were shorter in oral reading compared to the silent reading condition. Interestingly, reading aloud substantially reduced time spent refixating and rereading target words. In addition, word frequency effects were greatly reduced in all measures and almost completely absent in total reading time. The attenuation of word frequency effects may be explained by competing resource demands for language production. Long range regressions and re-reading of earlier words may be suppressed due to constraints of eye voice coordination during reading aloud (Inhoff, Solomon, Radach & Seymour, 2011). A tentative conclusion from these data is that reading aloud may have detrimental consequences for reading comprehension.

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Influence of a reading task on on-line text processing strategies in elementary school children: An eye movement study

Johanna K. Kaakinen, Annika Lehtola & Satu Paattilammi
University of Turku, Finland

The present study investigated the influence of a reading task on readers' on-line text processing strategies in a sample of 2nd (n = 18), 4th (n = 18), 6th graders (n = 22) and adults (n = 21). Participants read science texts adopted from elementary school textbooks with two tasks: 1) for comprehension and 2) in preparation to answer a comprehension-encouraging question. Participants' eye movements were recorded and after reading they answered two questions (a text memory question and a comprehension question). Basic word reading skill and text comprehension ability were assessed with standardized tests. The eye movement data were analyzed with linear mixed effects models in order to examine how reader-level characteristics (i.e., basic word reading skill) influence the ability to adjust on-line text processing strategies to the different reading task instructions (a text-level measure). The results are relevant to the theories of the development of reading skill as well as to the theories of eye movement control during reading.

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Inserting spaces in Japanese text affects reading speed both positively and negatively in children but only positively in adults

Nobuyuki Jincho[1] & Reiko Mazuka[1,2]
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Although Japanese text usually contains no spaces between characters, spaces are inserted in textbooks for 1st and 2nd graders. To investigate the effect of inserting spaces in Japanese text, this study recorded Japanese 2nd graders, 4th graders, and adults' eye movements when they read a text either with appropriate spaces dividing phrases, inappropriate spaces randomly dividing a letter sequence, or no spaces. We expected that appropriate and inappropriate spaces would facilitate and disrupt reading respectively compared to no-space texts if readers rely on spaces for recognizing words in a text. We investigated how total fixation time per phrase was affected by phrase type (kanji words or hiragana words), text type (appropriate, inappropriate, or no spaces), and age groups (adults and 2nd and 4th graders) in mixed effects models. The results demonstrated that total fixation times decreased by age. In all age groups, appropriate spaces decreased total fixation times compared to no space text. However, the disruption by inappropriate spaces decreased with age and the effect was not found in adults. These results suggest that inserting spaces affects the efficiency of text reading in children but that this effect lessens as they accumulate experience of reading texts with no spaces.

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The nature of interword space processing during reading: A comparison of young and older adults

Victoria A. McGowan, Sarah J. White & Kevin B. Paterson
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It is well established that the reading performance of older adults (65+) is poorer than that of young adults (18-30). Previous studies have indicated that the decline in spatial contrast sensitivity in older adults may lead to a greater reliance upon coarse scale visual information within a text. As the spaces in between words provide a coarse scale visual cue to a word's boundaries, two experiments were conducted in which eye tracking was used to explore whether manipulating space information between words during reading would affect young and older adults differently. In Experiment 1, sentences were shown to young and older readers which were either normally spaced, had interword spaces removed, or had interword spaces filled with open (□) or closed (■) squares. The results indicate that removing or filling interword spaces is particularly disruptive for older adults, especially when coarse visual cues for word segmentation are not available. Experiment 2 further examines whether older adults are more reliant upon interword spacing than younger adults by varying the amount of space that was present between words. The implications of these results for our understanding of how word segmentation processes are affected by age will be discussed.

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Talks

PETMEI 1

Tuesday, August 13, 10:20 - 12:00

Room: Sångsalen

Chairs: Andreas Bulling, Roman Bednarik

A Cheap Portable Eye-Tracker Solution for Common Setups

Onur Ferhat[1,2] & Fernando Vilariño[1,2]
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[2]Universitat Autonòma de Barcelona

We analyze the feasibility of a cheap eye-tracker where the hardware consists of a single webcam and a Raspberry Pi device. Our aim is to discover the limits of such a system and to see whether it provides an acceptable performance. We base our work on the open source Opengazer (Zielinski, 2013) and we propose several improvements to create a robust, real-time system. After assessing the accuracy of our eye-tracker in elaborated experiments involving 18 subjects under 4 different system setups, we developed a simple game to see how it performs in practice and we also installed it on a Raspberry Pi to create a portable stand-alone eye-tracker which achieves 1.62° horizontal accuracy with 3 fps refresh rate for a building cost of 70 Euros.

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EyeCloud: Cloud Computing for Pervasive Eye-Tracking

Hana Vrzakova & Roman Bednarik
University of Eastern Finland, Finland

In order to move away from limited laboratory studies to pervasive mobile contexts, eye-tracking needs to be combined with technologies that allow instant access to large amounts of data of a massive number of users simultaneously. Cloud-computing seems to offer the solutions for these needs. We map the research area from an interactive technology development point of view.

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Distributed Eye Tracking Network for Conveying Gaze of Remote Users in a Robotic Telepresence Scenario

David Rozado, Belinda Ward & Fred Pauling
ICT Centre - CSIRO, Australia

We propose a distributed network of eye trackers to monitor the gaze behaviour of multiple users of a remote telepresence system. Telepresence systems allow their users to sense a remote location as if they were physically present, and may also project images and audio from tele-present subjects into the physical environment – for example via a robot. However, a limitation of such telepresence systems is that for humans around the robot it is difficult to determine where the remote users are focusing their attention. This contrasts with physical presence where body language and other subtle cues provide a hint of gaze points. We use as an illustrative application a robot which facilitates remote museum visits. A panoramic camera on the robot provides remote users with an immersive view within the gallery, and a human museum guide directs the robot around the museum while interacting with the remote visitors. Eye trackers are used to collect information on where remote users are looking. The robot then superimposes this data into a condensed representation of the panoramic image on its display screen. The visualization of remote visitors' gaze behaviour provides useful feedback to the museum tour guide about their audience's areas of attention.

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Talks

Attention and salience

Tuesday, August 13, 14:30 - 15:50

Room: Stora salen

Chair: Antje Nuthmann

Direct control of fixation duration in visual search: The role of extrafoveal processing

Eyal M. Reingold[1] & Mackenzie G. Glaholt[2]
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Participants' eye movements were monitored in 2 visual search experiments that manipulated target-distractor similarity (high vs. low) as well as the availability of distractors for extrafoveal processing (Preview vs. No-Preview). The influence of the target-distractor similarity by preview manipulation on the distributions of first-fixation duration was examined by using a survival analysis technique (Reingold, Reichle, Glaholt, & Sheridan, 2012), which provided precise estimates of the timing of the first discernible influence of target-distractor similarity on first-fixation duration. Using this technique, we found rapid influences of target-distractor similarity on fixation duration in normal visual search (∼25 ms from the start of fixation). In contrast, the influence of target-distractor similarity occurred much later (∼200-235 ms from the start of fixation) in the No-Preview condition. The present findings provide strong support for the crucial role of extrafoveal processing in enabling direct control of visual search fixation times. Implications for models of eye-movement control are discussed.

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Parallel, independent foveal analysis and peripheral selection

Casimir J. H. Ludwig[1], J. Rhys Davies[1] & Miguel P. Eckstein[2]
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Models of eye movement control make strong assumptions about how analysis of the currently fixated information is coordinated with selection of the next saccade target. To what extent are foveal analysis and peripheral selection interdependent? Observers performed a visual comparison task in a limited period of time. A Gabor patch at fixation (the foveal target) fluctuated in contrast and orientation. The mean orientation was offset from vertical in either the clockwise or anti-clockwise direction. The magnitude of the offset was varied to create conditions of low and high foveal processing difficulty. Three peripheral patterns also fluctuated in contrast and orientation. One of the peripheral patterns (the peripheral target), had a higher mean contrast. Observers judged whether the peripheral target tilt was the same or different from the foveal target. A noise classification analysis identified the temporal epochs during which information from the fovea was used for the tilt discrimination and contrast information from the periphery was used to select the peripheral target. The extraction of information from the fovea and periphery occurs in parallel and independently. These results provide strong evidence in favour of parallel models of eye movement control.

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Covert attention within and beyond the Effective Oculomotor Range

Daniel Thomas Smith[1], Keira Ley[1] & David Pearson[2]
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[2]University of Aberdeen, UK

Covert spatial cognition is tightly coupled to the eye-movement system but the precise nature of this coupling remains contentious. Our recent research has focused on the idea that covert attention and overt eye-movements many share a common biological limit, such that attention can only be shifted to locations within the range of possible eye movements (the effective oculomotor range: EOMR). Here we describe data from two paradigms that investigate attentional orienting within and beyond the effective oculomotor range. In one task the motility of the eye was constrained by forcing participants to view stimuli with the eye abducted by 40 degrees into the temporal hemispace. In another the viewing position was canonical but stimuli were presented at eccentricities just within or just beyond the EOMR. The results showed a clear pattern. Exogenous shifts of attention were impaired when stimuli appeared beyond the EOMR whereas endogenous shifts of attention were not. Inhibition of Return was also observed beyond the EOMR. This pattern was observed in Posner-style cueing tasks and visual search tasks. The effect also generalised to a different measure of spatial cognition, spatial working memory. We consider the implications of these data for different theoretical models of spatial attention.

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Shifting attention to the dark side: The pupillary light response reveals the focus of attention

Sebastiaan Mathôt[1,2], Lotje van der Linden[1,2], Jonathan Grainger[1,2]& Françoise Vitu[1,2]
[1]Aix-Marseile Université, Laboratoire de Psychologie Cognitive, France
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When the eyes are exposed to an increased influx of light, the pupils constrict. This pupillary response is traditionally believed to be purely reflexive and not influenced by cognitive factors. Here we report that the pupillary light response is modulated by covert visual attention. Participants identified a peripherally presented target, while fixating a central gray area that was flanked by large bright and dark regions (i.e. dark left and bright right, or vice versa). The probable location of the target was indicated by a cue (visual or auditory across different experiments), which implicitly triggered a shift of attention to either the bright or the dark area. We found that covertly attending to a bright area causes a pupillary constriction, relative to attending to a dark area. Strikingly, based on pupil size alone, we could distinguish 'attend bright' from 'attend dark' trials with 64% accuracy (up to 75% accuracy for some participants). We propose that the pupillary light response is best viewed as a stereotyped response to a voluntarily selected target, and is in this sense similar to spatial eye movements such as saccades and smooth pursuit.

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Talks

Special symposium in Honour of Rudolf Groner, part 2

Tuesday, August 13, 14:30 - 15:50

Room: Nya fest

Chairs: Walter Bischof, Eva Siegenthaler

Recurrence Quantification Analysis of Abnormal Eye Movement Behaviour

Walter F. Bischof[1], Nicola C. Anderson[2], Kirsten A. Dalrymple[3] & Alan Kingstone[4]
[1]University of Alberta, Canada
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[3]Dartmouth College, USA
[4]University of British Columbia, Canada

Most current methods for eye movement analysis rely on basic descriptions of general eye movement behaviour such as saccadic response time, direction, amplitude, location, and distribution. We have adapted recurrence quantification analysis (RQA) to develop a powerful method for characterizing and analysing the temporal dynamic between saccades [Anderson, Bischof, Laidlaw, Risko, & Kingstone (in press). Recurrence quantification analysis of eye movements, Behavior Research Methods]. Using traditional methods of eye movement analysis, we recently concluded that eye movement behaviour of healthy humans who are viewing images through a small, gaze-contingent window provides a very good approximation of the abnormal eye movement behaviour of patients with simultanagnostia. In the present study, we examine whether this convergence is preserved when the dynamics of eye movements are considered. The RQA analysis yielded two fairly well separated groups of eye movement behaviour: one belonging to the patients and the healthy participants in the gaze-contingent condition, and the other belonging to healthy participants viewing images without the gaze contingent window. These results provide new evidence that gaze-contingent viewing behaviour is similar to that of simultanagnostic patients. They also demonstrate that RQA is a sufficiently sensitive tool for capturing differences in the temporal dynamics of eye movements.

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Scanpath Comparison Methods: Compared

Nicola Christine Anderson[1], Fraser Anderson[2], Walter F. Bischof[2] & Alan Kingstone[3]
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Eye movement behaviour is a rich source of information that contains not only a location, amplitude and duration, but also has a specific sequence, or scanpath, that unfolds over time. The temporal richness of eye movement data is typically investigated by comparing scanpaths across scenes and individuals. In the present work, we outline, review and compare several recent methods for scanpath analysis, and introduce a new method, cross-recurrence analysis [based on Anderson, Bischof, Laidlaw, Risko, & Kingstone (in press). Recurrence quantification analysis of eye movements, Behavior Research Methods]. Each of the methods for scanpath analysis was evaluated using scanpaths derived from an image encoding and recognition task [based on Foulsham & Underwood (2008). What can saliency models predict about eye movements? Spatial and sequential aspects of fixations during encoding and recognition. Journal of Vision, 8 (2):6, 2008, pp. 1-17]. Comparing scanpaths within and between participants, we evaluate the strengths and weaknesses, the power to detect an effect, and the specific scanpath measures (e.g. temporal structure and similarity of scanpaths) quantified by each method. We show that different methods of scanpath analysis capture different aspects of eye movement behaviour and present some recommendations on how to select an optimal method.

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Auditory targets in the study of the oculomotor control system

Daniela Zambarbieri
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When subjects are presented with auditory targets in space, the oculomotor control system receives from the auditory system suitable position information to program and execute saccadic responses toward the target. Since in this case retinal error is not available, the movement of the eyes is controlled in open loop condition, which represents the most critical situation for any control system. Therefore the use of auditory targets, either in head fixed and head free conditions, put in evidence oculomotor control strategies that normally do not manifest in tracking visual targets.

Experimental protocols in which different starting position of the eyes in the orbit are considered allow to create a difference between the craniotopic and retinotopic position of the auditory targets. The results clearly indicate that saccade latency depends on the relative position of the sound source with respect to the eyes, supporting the neurophysiological findings that auditory maps in the superior colliculus shift with changes in eye position.

Experimental studies of gaze orientation toward auditory targets strongly support the hypothesis that the control signals to the eyes and to the head are produced independently each other: coordination is guaranteed by the oculomotor control systems through efference copy signals of motor commands.

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An important word automatically catches eyes: A study with a dual task paradigm

Naoyuki Osaka[1], Takehiro Minamoto[2], Miyuki Azuma[1], Ken Yaoi[1] & Mariko Osaka[2]
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The present study tested a hypothesis that addressed whether executive attention is required to detect significant word in a given sentence. We challenged the research question, using the focused version of a reading span test (RST), which required executive attentional control. The focused version of the RST consists of two RSTs: focused RST and non-focused RST. In the focused RST, a target word corresponds to the word with core meaning in a sentence (focused word). In the non-focused RST, a word other than the focused word is designated to the target word. Therefore, focused words correspond to distractors that are irrelevant to task goal. In both tasks, participants were required to read four sentences while memorizing target words for a subsequent recall. We measured eye movement while participants performed the task, and analyzed eye fixation on targets as well as non-target distractors. If focused words require executive attention to be detected, fixation on focused distractors in the non-focused RST should be similar to that on non-focused distractors in the focused RST, as executive attention was directed to handle target items. The result showed significantly longer fixation on focused distractors in the non-focused RST, indicating that important words automatically catch attention.

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Talks

Eye-movement control during reading I

Tuesday, August 13, 14:30 - 15:50

Room: Lilla salen

Chair: Keith Rayner

Preview Benefit or Preview Cost?

Wayne S. Murray[1], Keith Rayner[2] & Laura J. Wakeford[1]
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We report the results of two studies employing the Boundary Paradigm (Rayner, 1975) to examine the nature of parafoveal preview benefit during reading. A display change was implemented as the eye left an adjective and moved to the following 6 letter noun. Preview of the noun was either identical or had all letters, the first 3 or last 3 masked with either randomised pixels, an illegal letter string maintaining or violating word shape or xxxs. There were no effects of the nature of the preview in the parafovea, or spillover effects after the eye left the previously-masked word, and no masking effect interacted with word frequency, but there were masking and frequency effects on inspection of the noun. All measures showed a larger effect of preview disruption with letter substitutions than with a random pixel mask, with xxx strings the most disruptive. Maintenance of word shape had no overall effect, but it did interact with the effect of masking half the word. Overall, the results suggest that orthographic mismatch between preview and direct inspection exerts an inhibitory effect that needs to be taken into account when selecting 'baselines' for the assessment of any sort of preview benefit.

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Parafoveal Processing of Spaced Compounds

Michael G. Cutter, Simon P. Liversedge & Denis Drieghe
The University of Southampton, United Kingdom

This study investigated n+2 preview benefit in reading spaced English compounds embedded in sentences, when word n+2 is the second constituent of a spaced compound (e.g. "bear" in "teddy bear"). The study used a 2 (n+1 preview: identity vs. non-word) × 2 (n+2 preview: identity vs. non-word) design in order to test whether n+2 preview benefit occurs in such items, and whether this was licensed by the availability of the first constituent. Prior n+2 boundary studies have only found an n+2 preview benefit when word n+1 was short and highly frequent. In our study n+1 was neither short nor highly frequent. Nevertheless, an n+2 preview benefit was found in various eye movement measures upon word n+1 when an accurate preview of word n+1 was available. Furthermore, a more general n+2 preview benefit was evident when the whole compound was analysed as a single interest area. This is the first time an n+2 preview benefit has been observed when n+1 was not necessarily easy to process. We argue that this novel finding is due to spaced compounds being processed as a single lexicalised element. The implications of these findings for the serial-parallel lexical processing debate will be discussed.

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Half preview benefit, half delayed cost: Evidence from reading with gaze-contingent preview manipulation of word n+1

Sarah Risse & Reinhold Kliegl
University of Potsdam, Germany

Preview benefit is thought to facilitate immediacy processing, resulting from successfully integrating information that was obtained when the word was still located in parafoveal vision. However, recent findings suggest that parafoveal processing of difficult previews exert a cost, and this cost can even be delayed into the next fixation [Risse & Kliegl, 2012, Journal of Experimental Psychology: Human Perception and Performance, 38, 1026-1042].

In order to investigate the impact of such parafoveal processing cost on the preview benefit, we conducted two gaze-contingent display-change experiments orthogonally manipulating the processing difficulty (i.e., word frequency) of an n+1 preview relative to the later target word at fixation. This allowed us to test both (delayed) cost and benefit and to dissociate their relative influence in fixation durations on the target word.

The results suggest that almost half of the preview benefit associated with word n+1 was attributed to delayed cost from parafoveal processing difficulties. Additional quantile regressions on the time course of the two preview effects provide further insight into the integration of foveal and parafoveal information across the perceptual span. The results are discussed with respect to their implications for computational models of eye-movement control in reading.

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Processing of parafoveal words in reading: Simulations with the SWIFT model

Sven Hohenstein, Sarah Risse & Ralf Engbert
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Eye movements in reading are influenced by features of words in foveal and parafoveal vision. Whereas preprocessing of the next word (n + 1) is undisputed, there is an ongoing debate concerning the influence of the next but one word (n + 2) on gaze control. We present results from a simulation study using an advanced version of the SWIFT model [Schad & Engbert, 2012, Visual Cognition, 20, 391-421]. In this model, the processing span is dynamically modulated by the processing state of the fixated word. In an extension, both foveal and parafoveal words can contribute to the modulation of size of the processing span. Implications of gaze-contingent display change experiments on distributed processing can be captured within the SWIFT framework. We applied the new implementations to experimental data and demonstrate that SWIFT is a viable model for eye-movement control during reading of words in foveal and parafoveal vision.

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Talks

PETMEI 2

Tuesday, August 13, 14:30 - 15:50

Room: Sångsalen

Chairs: Roman Bednarik, Andreas Bulling

Evaluation of accurate eye corner detection methods for gaze estimation

Jose Javier Bengoechea, Juan Jose Cerrolaza, Arantxa Villanueva & Rafael Cabeza
Public Unviversity of Navarra

Low cost eye tracking based on simple hardware such as web cams results in new obstacles that researchers working in the area need to overcome being gaze estimation one of the most challenging tasks. If no infrared light sources are employed the image quality decreases considerably and makes it difficult to use pupil center as tracking feature. Accurate detection of iris center and eye corners appears as promising approach for low cost gaze estimation. Since iris detection has been covered by previous works, in this paper we propose novel eye inner corner detection methods. Appearance and feature based segmentation methods are suggested. All these methods are exhaustively tested on a realistic dataset, i.e. Gi4E dataset, containing images of subjects gazing at different points on a screen. The results show promising conclusions regarding the use of these methods in real low cost eye tracking systems.

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A New 3D Line of Gaze Estimation Method with Simple Marked Targets and Glasses

Samil Karahan[1,2], Yakup Genc[2] & Yusuf Sinan Akgul[2]
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This paper presents a new Line of Gaze (LoG) method that uses a paper target with a hole for training and simple glasses for the head tracking. Both the target and the glasses are marked with fiducials for 3D localization and they are easy to construct. The system does not need any extra cameras or IR light sources. As opposed to many LoG methods in the literature, our method does not impose any restrictions on the user head movements or the LoG orientations, yet it produces low error rates comparable to the state of the art. The proposed method introduces many novel contributions such as a linear system for the cornea center and radius estimation and a new training method for preventing user errors. The experiments performed with users produced encouraging numerical results.

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A fully-automatic, temporal approach to single camera, glint-free 3D eye model fitting

Lech Swirski & Neil Dodgson
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We present a 3D eye model fitting algorithm for use in gaze estimation, which operates on pupil ellipse geometry alone, and so works with no user-calibration, and does not require calibrated lighting features such as glints. Our algorithm is based on fitting a consistent pupil motion model to a set of eye image. We describe a non-iterative method of initialising this model from detected pupil ellipses, and two methods of iteratively optimising the parameters of the model to best fit the original eye images. We also present a novel eye image dataset, based on a rendered simulation, which gives a perfect ground truth for gaze and pupil shape. We evaluate our approach using this dataset, measuring both the angular gaze error (in degrees) and the pupil reprojection error (in pixels), and discuss the limitations of a user-calibration-free approach.

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Automatic User Calibration for Gaze-Tracking Systems by Looking into the Distance

Takashi Nagamatsu, Tatsuhiko Ueki & Junzo Kamahara
Kobe University, Japan

To implement gaze-tracking without user-calibration, the offsets between the optical and visual axes of the eyes are estimated. Existing studies propose automatic user-calibration methods where the user gazes at a computer display. We propose an automatic user-calibration method where the user looks into the distance, which is suitable for drivers of cars, trains, and ships, who spend much of the time looking into the distance. We calculate the offsets between the optical and visual axes of the eyes based on the fact that the visual axes of both eyes are always parallel when the user looks afar, irrespective of the direction of the gaze. We evaluated the proposed method by computer simulation and a user experiment using an experimental system.

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Talks

Dynamic scenes

Tuesday, August 13, 16:10 - 17:30

Room: Stora salen

Chair: Michael Dorr

Gaze Coherence in Movies: Adaptations to the Normalized Scanpath Saliency

Frank Papenmeier, Konstantin Sering & Markus Huff
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When watching movies, gaze coherence across multiple observers varies over time. Objects entering the screen or object motion onset, for example, can cause times of high coherence (low variability). Drawing valid inferences based on gaze coherence needs measures that compute robust and easy to interpret estimates for gaze coherence. One measure for gaze coherence with dynamic stimuli is the Normalized Scanpath Salience (NSS) extended to the temporal domain (Dorr et al., 2010, Journal of Vision). We propose an adaptation to this measure, in particular regarding the normalization procedure and inclusion of the temporal domain. We compare these two methods according to their robustness, especially towards changes in the number of recorded participants, the amount and abruptness of changes in gaze coherence, and the size of the sliding time window used for calculations. In addition to the presentation of simulated gaze data, we also compare those measures with gaze data of real participants. We conclude that NSS provides an easy to use metric for calculations of gaze coherence in movies. Applying our adaptations helps to further improve the robustness of the computed NSS values and leads to a straight forward interpretation of the resulting NSS values.

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Uncanny gaze prediction in film: Validating Sergei Eisenstein's scanpath for Alexander Nevsky (1938)

Tim J. Smith
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In order to optimise viewer comprehension a film director needs to know where viewers are likely to look. Such intuitive gaze prediction is scattered throughout film theory even though comparable scientific insight into gaze behaviour in dynamic scenes is virtually lacking. For example, in Film Sense (1943) Russian film director Sergei Eisenstein provided a shot-by-shot analysis of a sequence from his film Alexander Nevsky (1938), including his prediction of an idealised scanpath. Eisenstein believed the scanpath was created by the correspondence between changes in the musical score (audio) and shot composition (visuals). In order to validate Eisenstein's intuited scanpath 26 participants free-viewed the film sequence with or without soundtrack whilst their eye movements were recorded. The causal influence of audiovisual correspondences on viewer gaze was not supported by the data. No significant differences were found in saccade amplitudes, fixation durations or locations in either audio condition. However, Eisenstein's predicted scanpath was partially validated by the average scanpath of all viewers. Large vertical gaze shifts following cuts mirrored the vertical trajectory of Eisenstein's predicted scanpath and also matched pitch changes in the accompanying soundtrack. The implications of such filmmaker intuitions for models of gaze control in dynamic scenes will be discussed.

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The influence of emotion on eye fixations for Hollywood movies

David Melcher[1], Ramanathan Subramanian[2], Divya Shakar[1] & Nicu Sebe[1]
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In order to study eye movement fixation patterns during naturalistic viewing, movies provide a valuable bridge between well-controlled studies of static images and more ecological but uncontrolled studies of real-world environments. Popular movies are designed to entertain viewers, in particular by manipulating emotional responses. In a romantic comedy, for example, a visually similar stimulus may evoke laughter or tears, or be relatively neutral in emotional tone. We investigated the influence of emotional valence on eye fixation patterns, as well as subsequent memory for visual and dialogue details. Compared to neutral movie clips, eye fixations when watching emotional clips were less spread out across the image and were more idiosyncratic, suggesting that emotion focused the attention (and fixations) of participants to a specific part of the scene. This effect was also mirrored by memory for peripheral object details, which was better for neutral clips than emotional ones. Overall, these results are consistent with the hypothesis that emotional content focuses fixations to a specific location within the scene, weakening encoding of peripheral scene details.

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Changes in blinking behavior while watching videos with reduced quality

Robert Schleicher, Sebastian Arndt & Jan-Niklas Antons
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This study examines the effect of quality impairment on eye blink behavior while watching HD movies. Subjects watched eighteen minutes excerpts from a HD movie of sea-life scenes in original quality as well as with a reduced bitrate, a common impairment when streaming audiovisual material. Each six minutes, subjects rated the perceived video quality on a standardized scale. Order of presentation was randomized across subjects. The version with reduced bitrate was rated to be of significantly lower quality than the high-quality version.

Eye movements were recorded using electrooculogram (EOG), and blinks were extracted semi-automatically using a freely available software for Matlab. All blink parameters were normalized subject-wise using the first two minutes of each video block as a baseline. Average blink duration was significantly higher for the lower quality video, indicating a fatiguing effect caused by the quality impairments. These results suggest that blink parameters can be deployed to assess the tonic effects of reduced video quality on the viewer.

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Talks

Special symposium on Empirical approaches to gaze data analysis in reading, writing and translation

Tuesday, August 13, 16:10 - 17:30

Room: Nya fest

Chair: Michael Carl

Scanpaths in reading are tractable and informative

Titus von der Malsburg, Shravan Vasishth & Reinhold Kliegl
University of Potsdam, Germany

Pioneering work in reading research has shown that scanpaths in reading can be informative about sentences processing (Frazier, Rayner, 1982). Nevertheless, scanpaths have not gained much traction in reading research. One reason for that may have been a lack of suitable analytical tools. Here, we summarize three recent studies in which we used a new scanpath measure to analyze gaze data from two experimental studies (von der Malsburg, Vasishth, 2011, 2012) and one corpus study (von der Malsburg, Kliegl, Vasishth, under revision). The experiments investigated how readers process temporarily ambiguous sentences. We showed that readers do not always commit to one of the alternative interpretations, and that readers with low working-memory capacity do so less often. Contrary to what was reported earlier, we found that reparsing instead of targeted repair is a common strategy to recover from incorrect interpretations. Interestingly, these results did not emerge in an analysis using traditional word-based eyetracking measures showing their limitations. In the corpus study, we demonstrated how syntax, oculomotor constraints, and age of reader jointly determine the regularity of scanpaths. We argue that, taken together, these results establish the scanpath as an informative and tractable object of investigation in reading research.

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Eye-movements during translation: large-scale analyses using the CRITT TPR database

Laura Winther Balling
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Translation process research or TPR, the study of the cognitive processes involved in translation, is a relatively new field characterised by small-scale studies with few participants and variables. However, the translation process is characterised by much variation between different translators, texts, tasks and languages, and larger-scale investigations are therefore highly desirable. To that end, we have publicly released the CRITT TPR database which currently contains data from 845 translation sessions but is continually extended. The database includes information about the source and target texts as well as both eye-tracking and keylogging data.

Based on this database, I present a large-scale analysis of gaze on the source text based on 91 translators' translations of six different texts from English into four different target languages. I use mixed-effects modelling to compare from-scratch translation with post-editing of machine translated texts, uncovering similarities and differences between the two processes, overall and in interaction with other variables also investigated. These include gaze and keystroke behaviour, word and n-gram probabilities, participant variables including expertise, and variables indexing the alignment between the source and target texts. The results are related to current models of translation processes and reading and compared to a parallel analysis of production time.

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Dynamic programming for re-mapping noisy fixations in translation tasks

Michael Carl
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Eyetrackers which allow for free head movement are in many cases imprecise to the extent that reading pattern become heavily distorted. As a result, a "naïve" gaze-to-symbol mapping approach wrongly maps also the drifted center of the fixation on the symbol directly below it. In this talk, I extend this "naïve" gaze-to-word mapping by introducing background knowledge about the gazing task. In a first step, the sequence of "naïve" gaze-to-symbol mappings is projected into a lattice of several possible gaze locations above and below the current fixation on the text. In a second step a dynamic programming algorithm applies a number of heuristics to find the best path through the lattice, based on the likely distance in characters and in pixels between successive fixations, so as to smooth the gazing path according to observations reported in the established literature.

I present several types of drifting problems and noise that we observe when using eyetrackers to record and analyse gazing behavior of translators. I describe the mapping algorithm and show how it rectifies and re-aligns the noisy gaze data to provide a more intelligible gaze path. I show examples of re-mapped fixations which better explain translator's activity than naïve gaze-to-symbol mapping.

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Eye-data to Validate Readability Models for Diagnosis

Pascual Martinez-Gomez & Akiko Aizawa
The University of Tokyo, National Institute of Informatics

The objective of readability studies is to find linguistic features and design discriminative models that predict a readability score such that correlates well with human judgment. But correlation does not imply causality, and discriminative models fail at recognizing the causes of readability. The capability to recognize those causes is important in the development of authoring systems that assist humans in creating content, and in building systems for automatic text transformation such as machine translation, text summarization or readability optimization. With the objective of diagnosing the causes of readability, generative approaches are necessary to model readability. However, those models are difficult to be tested or validated with ground truth. Causes of readability can be expressed in the form of an accurate quantification of positive or negative influence of linguistic features into readability. In this work, we discuss how eye-data can be used to test how well a generative model explains the causes of readability, using the quantification estimated by the model and a function of eye-data on the individual linguistic features of the text. This work contributes to the development of a common framework to test generative readability models on cognitive evidence via eye-data.

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Talks

Eye-movement control during reading II

Tuesday, August 13, 16:10 - 17:30

Room: Lilla salen

Chair: Eyal Reingold

The time-course of lexical influences on fixation durations during reading: Evidence from distributional analyses

Heather Sheridan & Eyal M. Reingold
University of Toronto Mississauga, Canada

Although it is well-established that fixation times during reading are influenced by lexical variables, competing models of eye movement control in reading disagree about the time-course of these lexical influences. To address this controversy, we used distributional analyses of fixation times to examine the time-course of three prominent lexical variables. Specifically, we manipulated contextual predictability by presenting target words in a high-predictability versus a low-predictability prior context (Experiment 1), we manipulated lexical ambiguity by presenting biased homographs in a subordinate-instantiating versus a dominant-instantiating prior context (Experiment 2), and we manipulated word frequency by contrasting high-frequency and low-frequency target words (Experiment 3). Ex-Gaussian fitting (Staub, White, Drieghe, Hollway, & Rayner, 2010) revealed that all three lexical variables were fast-acting enough to shift the entire distribution of fixation times, and a survival analysis technique (Reingold, Reichle, Glaholt, & Sheridan, 2012) revealed extremely rapid lexical effects. Taken together, these findings support models of eye movement control that assume that lexical variables can have an early influence on fixation durations.

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Spontaneous re-reading within sentences: Eye movement behaviour and visual sampling

Sarah J. White, Laura M. T. Lantz & Kevin B. Paterson
University of Leicester, United Kingdom

Three experiments are presented that explore the processes underlying spontaneous re-reading within sentences. The studies employ a saccade contingent change technique such that text more than one word to the left of fixation disappears (or is masked) as the eyes move through the sentence, and the text either remains absent or re-appears during re-reading. Experiments 1 and 2 compare the effects of different types of masks (X mask with spaces, X mask without spaces, visually similar, blank). The results show that reading rates and comprehension accuracy can remain high even when text is unavailable for re-reading, indicating that visual re-sampling during re-reading within sentences isn't always necessary. The results further indicate that line position, word object and word shape cues are important for eye movement control during re-reading. Experiment 3 employed the same methodology with more complex sentences. Re-reading times were longer when the text re-appeared, even though comprehension was unaffected by text availability. The results indicate that visual re-sampling of meaningful text is important in eye movement control, but not necessarily comprehension, during re-reading for more difficult sentences. The implications of the results for our understanding of the mechanisms underlying eye movement control during spontaneous re-reading will be discussed.

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Using E-Z Reader to Examine Fixation-Location Measurement Error

Erik Reichle[1] & Denis Drieghe[2]
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There is an on-going debate about whether fixation durations during reading are only influenced by the processing difficulty of the words being fixated (i.e., attention is allocated serially) or whether they are also influenced by the processing difficulty of the previous and/or upcoming words (i.e., attention is allocated as a gradient). The results of three simulations are reported examining how systematic and random error in the measurement of fixation locations can generate two phenomena that suggest parafoveal lexical influences used to argue against the serial-attention hypothesis—parafoveal-on-foveal effects and large spillover effects. These simulations indicate how such effects can result from measurement error within the context of a computational model (E-Z Reader; Reichle, 2011) that instantiates the serial allocation of attention, thus demonstrating that reports of these effects do not necessarily provide strong evidence against the serial-attention hypothesis.

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Are Parafoveal Effects of Word Frequency and Predictability due to Distributed Processing or Mislocated Fixations?

Reinhold Kliegl, André Krügel & Ralf Engbert
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Parafoveal effects of frequency and predictability on fixation durations are theoretically controversial and empirically ambiguous. Theoretically, they are interpreted as evidence for distributed processing or saccadic error. Empirically, in German, both frequency and predictability effects of the fixated word are reported as negative, whereas those associated with the frequency and predictability of the upcoming word are negative and positive, respectively (e.g., Kliegl, 2007, JEPGen). We estimated the most likely fraction of mislocated fixations for every letter with a self-consistent iterative algorithm, relative to overall fixation landing-position distributions and word-selection probabilities (Krügel & Engbert, 2010, VisionRes), and compared frequency and predictability effects for observed and estimated ("corrected") fixation locations. There are two predictions: (1) If effects were due to mislocation, they should be reduced or eliminated after "correction" for mislocation. (2) If observed effects had "survived" despite mislocation of a proportion of fixations, they should be stronger for "corrected" than observed fixation locations. Results relating to effects of the fixated word and its left and right neighbor were maintained or stronger for corrected fixation locations, that is they were only in agreement with the second option. Therefore, it is highly unlikely that mislocated fixations are the sole source of parafoveal effects.

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Finger tapping predicts text comprehension

Victor Kuperman[1], Priscilla Ally[1] & Julie A. Van Dyke[2]
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The ability to program rapid serial saccadic movements is a central component of acquiring reading proficiency (Biscaldi et al., 1998; Olson et al., 1983). This paper explores whether successful text comprehension, and associated eye-movements, are also predicted by the ability to coordinate rapid serial non-oculomotor movements. Forty typically developing undergraduate students were asked to tap sequences of computer keys either with one or multiple fingers to test their motor coordination (Carello et al, 2002). They were also asked to silently inspect grids of digits/letters and read texts of varying complexity, while their eye-movements were recorded. Mean duration and variance of intertap intervals were correlated with each participants' eye-movements during grid reading and text reading. Slow or irregular tapping came with increased rates of skipping and regressions in both grid and text reading (all $r > 0.2$, all $p < 0.01$). Tapping measures also jointly explained over 5% of unique variance in individual comprehension scores, gauged via multiple-choice questions. Our results show for the first time that imperfect muscular coordination in serial tasks that are not learned or related to the visual system (a) correlates with imprecise oculomotor control and (b) contributes to impoverished reading skill even in proficient readers.

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Talks

PETMEI 3

Tuesday, August 13, 16:10 - 17:30

Room: Sångsalen

Chair: Päivi Majaranta

Using Gaze Based Passwords as an Authentication Mechanism for Password Input

David Rozado
CSIRO, Australia

Traditional knowledge-based authentication techniques such as inputting a password with a keyboard are vulnerable to malicious observers using direct observation techniques (such as shoulder surfing) to grab user's authentication credentials. Videoculography gaze tracking can be used to input a password into a computer by gaze in a manner that is shoulder surfing resistant such as for instance by looking at a sequence of spatial positions in an image. I propose here two new gaze-based password input mechanisms: the usage of predefined gaze gestures and the smooth pursuit of a sequence of moving targets. A user study is presented comparing the speed and error rates of inputting a password using different gaze-based password methods as opposed to a traditional keyboard-based password. I also propose to utilize the user-specific gaze estimation parameters gathered during a calibration procedure for rendering impractical to another person to input a password by gaze even if the impostor knows the appropriate password. I show empirically how correct gaze-based passwords are not recognized by the system when using the gaze estimation parameters of a different user. The results of this work suggest the feasibility and advantages of using gaze-based methods for authentication purposes with a computer system.

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Estimating Focused Object using Corneal Surface Image for Eye-based Interaction

Kentaro Takemura[1], Tomohisa Yamakawa[2], Jun Takamatsu[2] & Tsukasa Ogasawara[2]
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In head-mounted camera systems such as Google's Project Glass and First Person Vision, researchers are considering the use of eye tracking. However typical eye-tracking methods require a detailed calibration in advance, and long periods of use break the calibration record about the relationship between eye and scene camera. Additionally, even if the point-of-regard is estimated using a portable eye-tracker, the focused object cannot be estimated. Therefore, we propose a novel method to estimate the object that the user is focusing on by using an eye camera that captures the reflection on a corneal surface. Eye and environment information can be extracted simultaneously from the corneal surface image. We use inverse ray tracing to rectify the reflection image, and scale-invariant fea-ture transform to estimate the object on which the point-of-regard is located. We believe that our proposed method can be applied to a guide system, and we confirmed feasibility of guide system through some experiments.

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Interacting with Objects in the Environment by Gaze and Hand Gestures

Jeremy Hales[1], Diako Mardanbeigi[2] & David Rozado[1]
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A head-mounted wireless gaze tracker in the form of gaze tracking glasses is used here for continuous and mobile monitoring of a subject's point of regard on the surrounding environment. We combine gaze tracking and hand gesture recognition to allow a subject to interact with objects in the environment by gazing at them, and controlling the object using hand gesture commands. The gaze tracking glasses was made from low-cost hardware consisting of a safety glasses' frame and wireless eye tracking and scene cameras. An open source gaze estimation algorithm is used for eye tracking and user's gaze estimation. A visual markers recognition library is used to identify objects in the environment through the scene camera. A hand gesture classification algorithm is used to recognize hand-based control commands. When combining all these elements the emerging system permits a subject to move freely in an environment, select the object he wants to interact with using gaze (identification) and transmit a command to it by performing a hand gesture (control). The system identifies the target for interaction by using visual markers. This innovative HCI paradigm opens up new forms of interaction with objects in smart environments.

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Image Preference Estimation from Eye Movements with A Data-driven Approach

Yusuke Sugano, Hiroshi Kasai, Keisuke Ogaki & Yoichi Sato
The University of Tokyo, Japan

Understanding how humans subjectively look at and evaluate images is an important task for various applications in the field of multimedia interaction. While it has been pointed out over the years that eye movements can be used to infer the internal states of humans, there have not been many successes concerning image understanding. In this work, we investigate the possibility of image preference estimation based on a person's eye movements in a supervised manner. A data set of eye movements is collected when the participants are viewing pairs of natural images, and it is used to train an image preference label classifiers. The input feature is defined as a combination of various fixation and saccade event statistics, and the use of the random forest algorithm allows us to quantitatively assess how each of the statistics contributes to the classification task. The proposed classifier achieved a higher level of accuracy than the metadata-based baseline methods and a simple rule-based classifier.

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Talks

Social gaze I

Wednesday, August 14, 10:20 - 12:00

Room: Stora salen

Chairs: Alan Kingstone, Mary Hayhoe

Potential social interactions modulate social attention in dynamic scenes

Nicola Jean Gregory[1,2] & Beatriz Lopez[2]
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[2]University of Portsmouth, United Kingdom

Research investigating eye gaze following using spatial cueing paradigms has lacked considerably in ecological validity. The paradigms employed to date, first use static images and, second, participants lack genuine social involvement in the task. This study sought to address this issue by showing participants videos of a social scene where two actors interacted in a waiting room whilst participants' eye movements were recorded. The actors each performed three overt head/ gaze shifts during the video. All participants were instructed that they were watching a live webcam to another room. Half the participants were told they would later perform a task with the actors in the video ("socially engaged" ; N = 20) whilst the other half were not ("non-engaged"; N = 21). Only a third of the head/gaze shifts were followed overtly by the participants, but more time was spent looking at the gazed-at side of the screen after the gaze shifts than before them, regardless of the level of social involvement. However, the socially engaged participants looked at the actors' heads for longer than the non-engaged group. These results suggest that a potential social encounter may modify attention to others but not the likelihood of following gaze.

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The relationship between eye movements during encoding and confirmation and hindsight biases

Christopher James Hand, Louise Maxwell & Graham George Scott
University of Bedfordshire, United Kingdom

The current study examines expectancy and outcome influences on text processing and hindsight and confirmation biases (HSB, CB; Carli, 1999), using a set of highly-controlled stimuli. A 2 (expectancy: positive, negative) × 2 (emotional content: positive, negative) × 2 (outcome: positive, negative) mixed-factors design was used. Expectancy was established by informing participants of a to-be-read vignette outcome. Participants read identical vignettes describing a romantic couple, containing equal numbers of positive and negative emotion words and events. The final sentence determined outcome: positive (a marriage proposal) or negative (a sexual assault). Participants then engaged in a distractor task, before being asked to recall verbatim the vignette content. Finally, psychometric measures of sexual attitudes and behaviour were collected.

The current paper investigates the effects of expectancy, outcome and emotional content on eye movement behaviour during encoding. We also examine such factors' effects on both HSB and CB. Furthermore, we investigate the relationship between stimulus processing, indexed by eye movement behaviours, and subsequent biases in stimulus recall. The outcomes of our analyses have profound implications for the understanding of the factors which can mediate or exaggerate the occurrence of such biases in recall.

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Comparing effects of speaker gaze and action information on anticipatory eye movements during spoken sentence comprehension

Helene Kreysa[1], Eva M. Nunnemann[2] & Pia Knoeferle[2]
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[2]Bielefeld University, Germany

Action depictions and the speaker's gaze direction have both been shown to facilitate the understanding of spoken sentences. However, relative differences in the time-course and manner of these effects are largely unexplored. We recorded participants' fixations as they watched videos of a speaker producing a transitive sentence involving two out of three depicted characters, such as "The waiter congratulates the millionaire". We varied whether the speaker could be seen shifting gaze from the agent (the waiter) to the patient (the millionaire), and whether objects illustrating the action denoted by the verb appeared between the two characters. Both types of cue allowed participants to anticipate the upcoming mention of the patient, so Experiment 1 compared speaker gaze against a single semantically related action cue. Experiment 2 contrasted speaker gaze with two action cues, of which only one matched the verb. Both speaker gaze and verb-related objects led to substantial increases in anticipatory fixations, though with differences in timing and extent. Unlike the suddenly onsetting objects, the speaker was rarely fixated directly, resulting in earlier patient fixations in the speaker gaze condition than with appearing objects. We will discuss the integration and relative priority of different contextual cues in online comprehension.

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Do you look where I look? Eyes bias where you look, but overt gaze following is inhibited by direct top down control!

Gustav Kuhn
Goldsmiths, University of London, United Kingdom

Observing faces with averted gaze results in shifts of attention in the direction of the eye gaze, which is known as gaze following. Covert gaze following (i.e. no eye movements) occurs even when the gaze cue is counter-predictive of the target location, thus illustrating that covert gaze following is resistant to direct top-down control. Using a modified overt visual search task we demonstrated that overt gaze following (i.e. where people look) is inhibited by direct top-down control. In experiment 1 participants were required to search for a target that either appeared at the looked at location or in the opposite location. Significant overt gaze following was found when the gaze was predictive and non-predictive of the target location, but not when the gaze was counter-predictive. Although gaze cues biased where participants looked, participants could inhibit the gaze cues. Experiment 2 showed that participants inhibited overt gaze following when the gaze cue pointed in a task irrelevant direction. I propose a new model of social cognition that highlights functional differences between overt and covert gaze following, which explains the different levels of top-down control over these types of attentional orienting.

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A Model of Joint Attention for Humans and Machines

Nadine Pfeiffer-Lessmann, Thies Pfeiffer & Ipke Wachsmuth
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Joint attention is the simultaneous allocation of attention to a target as a consequence of attending to each other's attentional states. It is an important prerequisite for successful interaction and supports the grounding of future actions.

Cognitive modeling of joint attention in a virtual agent requires an operational model for behavior recognition and production. To this end, we created a declarative four-phase-model (initiate / respond / feedback / focus) of joint attention based on a literature review. We applied this model to gaze communication and implemented it in the cognitive architecture of our virtual agent Max. To substantiate the model regarding the natural timing of gaze behavior, we conducted a study on human-agent interactions in immersive virtual reality. The results show that participants preferred the agent to exhibit a timing behavior similar to their own.

Building on these insights, we now aim at a process model of joint attention. We are interested in patterns of joint attention emerging in natural interactions. In the preliminary results of a human-human study, we find patterns of fixation targets and fixation durations that allow us to identify the four phases and infer the current state of joint attention.

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Talks

Visual search

Wednesday, August 14, 10:20 - 12:00

Room: Nya fest

Chair: Iain D. Gilchrist

Active Vision: The Influence of Target Function on Visual Search Strategies

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Visual processing is not an end in itself: it is generally in the service of some goal, often in the performance of an action (Gibson, 1979). Previous research has shown how an object is acted upon can also affect visual perception (e.g., Triesch et al., 2003). Here, we investigated whether how an object is used affects visual search strategies. In Experiment 1, two participant groups studied either some invented objects' function (Function group) or their visual features (Feature group). When searching for these objects in a scene, the Function group was more efficient (shorter target latency and fewer number of fixations) for the studied objects compared to novel objects, but there was no difference between objects types for the Feature group. In Experiment 2, invented objects were positioned in scene areas that were either congruent or incongruent with their function. A Function group found the objects more efficiently in congruent locations. Because no participants had previously seen the invented objects in a scene, improved search efficiency cannot be attributed to knowledge of their placement within scenes. We suggest that the nature of our physical interactions with an object positively influences search strategies and optimizes the use of scene context.

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To what extent does target/scene expectations influence search behaviour using the 'flash-preview moving window'?

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A brief glimpse of a scene can be used to guide subsequent eye movement behaviour but how does prior activation of target knowledge influence early scene processing and later eye movements? We manipulated whether target identity was presented before or after preview and found that windowed search for a target was more efficient following a 250ms scene preview, whereas presenting the target word prior to scene preview led to further improvements in how search was initiated and executed. However, in a second experiment when the target object was not visible during scene previews only eye movement metrics reflecting the initiation of search continued to be modulated by prior target knowledge. Finally a third experiment provided new evidence to suggest that this scene preview benefit can occur even when participants are searching through the same type of scene for the same type of targets. We discuss how the processing of target-features and scene context allows for better planning of eye movements, and highlight how the flash-preview paradigm could be applied to tasks where prior activation and expectation of target/scene knowledge is unavoidable.

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Low Target Prevalence Weakens Target Templates During Visual Search

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Two experiments tested the activation strength of different target templates during dual-target visual search. We manipulated the proportion of trials in which each of two targets appeared (the target prevalence). This enabled us to assess whether reductions in prevalence weakened the activation strength of target templates. Based on prior experimentation, we predicted that a reduction in prevalence may influence either guidance or identification processes during search (or both). We recorded eye-movements during search for one target that was presented on 45% of trials and a second target that was presented on 5% of trials. Participants were less likely to detect the lower-prevalence target than the higher-prevalence target. The eye-movement data revealed that both guidance and object identification processes were weakened for the lower-prevalence target: Participants were slower to fixate the lower-prevalence target than the higher-prevalence target, and, once fixated, required more time to identify the lower-prevalence target. A control experiment ensured that our results could not explained by performance decrements known to occur in dual-target search. Our results demonstrate that low target prevalence weakens target templates, thereby explaining why and how participants frequently miss low-prevalence targets.

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Eye guidance in search: Spatial inconsistency of targets but not distractors interferes with search

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We investigated how expectations about where objects should be placed in real-world scenes guide search. Previous work suggests that correctly placed objects facilitate attentional guidance, but also that objects violating plausible spatial associations may receive prioritised attention. In the present study we considered the relationships between objects and their scene placement (plausible or implausible) and how they relate to the precision of the target representation formed prior to search (verbal or visual). Placing the target in an unexpected location reduced eye movement efficiency in search initiation, scene scanning and target verification. When target objects were incorrectly placed, eye movements were directed to objects in the expected region on around 50% of trials. In these cases, eye movements targeted plausibly- and implausibly-placed distractors equally often. As such, inconsistently-placed distractors do not receive attentional priority. Across all measures, a specific target template enhanced search performance, and reduced fixations on inconsistent distractors. This study suggests that spatial inconsistency weakens context guidance rather than grabs attention, and that the disruption of search efficiency due to misleading expectations can be largely overcome by having detailed information about the target object.

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Validity of visual search patterns while watching a computer screen

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Introduction. In sports and traffic education settings, watching video clips on a PC screen are used for the education of attention. An implicit assumption of this technique is that visual search patterns will be comparable to the real-life situation. Methods. First, six fencers (two female, age 17,17 ± 3,66) watched three videoclips (± 3s) of an opponent fencer performing an attacking movement, projected on a large screen (2m x 3m) and performed a defending movement. Eye movements were recorded with a Head mounted Eye tracking Device (HED - SMI, 50Hz). Second, participants watched the same clips on the Remote Eye tracking Device (RED - SMI, 120Hz) on a PC screen (22"), from a seated position. Analysis. 11 Areas of Interest (AOIs) were chosen for the frame-by-frame analysis of RED and HED results. Gaze duration for each AOI was measured for both RED and HED. An intraclass correlation between HED and RED glance duration for each AOI was conducted. Results. An ICC of 0,656 (p=0.007) indicates moderate validity. Conclusions. Eye movements recorded with RED while seated were different from visual behaviour recorded with HED while executing corresponding fencing actions. This partly jeopardizes the use of PC-based video clips for tactical training in sport.

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Talks

Microsaccades

Wednesday, August 14, 10:20 - 12:00

Room: Lilla salen

Chair: Bruce Bridgeman

Statistical and fractal characteristics of microsaccades

Rostislav Belyaev[2], Vladimir Kolesov[2], Galina Menshikova[1] & Victor Ryabenkov[2]

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The statistics of spatial distributions of eye movements during the fixation plays an important role in the processes of visual search. The aim of our study was to investigate the statistical parameters of microsaccades and to verify the conformity of their spatial distributions to the normal Gaussian process. The images with different spatial structure were used as stimuli: drawings consisting of horizontal-vertical lines or graphic fractals. The study was carried out with the help of iView X Hi-Speed 1250 technique. The obtained data were processed to get microsaccade amplitude distributions and distributions of radial densities of start/end microsaccade landing points within the spatial structure of the fixation. The comparison of experimental characteristics with model characteristics obtained for random Gaussian process was done. It was shown that amplitude distributions of microsaccades differed from the normal and could be approximated by power functions, i.e., considered as fractal distributions. The fractal dimensions of eye movement patterns were calculated. It was revealed that the fractal dimension was a strictly individual factor for each observer. This result could allow using this parameter as a marker of visual search individual strategy.

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Saccades and microsaccades in a scanning task: Experiment and modeling

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We asked human observers to perform a scanning task with small items presented on a linear chain with distances less than 1 degree of visual angle. As a result, we observed small scanning saccades along the chain as well as microsaccades not related to sequential gaze shifts along the chain of items. Interestingly, the saccades and microsaccades could be distinguished by their correlation to slow drift movements before the saccadic events. Next, we applied an integrated model of fixational eye movements and microsaccades (Engbert, Mergenthaler, Sinn, & Pikovsky, 2011, PNAS) to reproduce the statistics of slow drift movements, microsaccades, and saccades. The model was able to predict the correct statistical dependency between saccadic events and drift movements. Our model simulations are compatible with the view that small scanning saccades and microsaccades are generated by the same mechanism.

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Attention shifts following spontaneous microsaccades

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Purpose: Previous studies used cued-attention protocols to show that microsaccade direction tends to follow the cue, supporting the hypothesis that microsaccades index the locus of attention. But microsaccades occur spontaneously at a rate of 2-3 Hz, even during passive fixation in the absence of a cue. Here, we used an uncued-attention protocol to test whether the direction of spontaneous microsaccades reflects shifts of attention and whether microsaccades and attention are inherently linked.

Methods: Subjects fixated a cross while microsaccades were detected from the streaming eye position data. Detection of a microsaccade triggered the appearance of eight peripheral grating patches surrounding the fixation cross (Expt 1) or the gaze position at the time of stimulus onset (Expt 2). The grating patches were followed by a central arrow indicating the target location, which was either congruent or incongruent (opposite) with respect to microsaccade trajectory. The task was to report the tilt direction of the target grating.

Results: Accuracy rates were higher for "congruent" than for "incongruent" trials, in both experiments.

Conclusion: the direction of microsaccades occurring during fixation (with no cue) is linked to spontaneous fluctuations in the locus of spatial attention.

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Similarities and differences in eye movements while viewing and visualizing simple and complex objects

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The aim of study was to test the similarity between perception and imagination in visual fixation times at corresponding regions of interest (cf. Laeng, Teodorescu, 2002) for simple and complex objects. Attempt was also made to find differences between watching and visualizing the object in eye movements (cf. Nakatani, Pollatsek, 2004).

Two experiments were conducted. In the first (48 subjects) the influence of factors modifying the strength of similarities in the visual fixation time on the corresponding regions of interest between seeing and visualizing the object was tested. Greater similarity between seeing and visualizing for simple objects, compared to complex was observed. Stronger similarity between perception and imagination for longer deferral between watching and imagining the object has been shown.

The second experiment (20 subjects) was performed in mental rotation paradigm. Similarity between perception and imagination in visual fixation times for the corresponding regions of interest was observed. The study also allowed to establish the differences between the processes of viewing and visualizing in eye movements. During visualizing the average fixation durations were longer and the number of fixations was lower. It can be argued that the imagination take longer, deeper data processing than it does when viewing an object.

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Microsaccades and Working Memory

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Microsaccade rates and directions were monitored while observers performed working memory tasks at varying retinal eccentricities. We show that microsaccades generate no interference in a working memory task, indicating that spatial working memory is at least partially insulated from oculomotor activity. Intervening tasks during the memory interval affected memory as well as microsaccade patterns. Average microsaccade rate peaks after appearance of a fixation cross at the start of a trial, and dips at cue onset and offset. Direction of stimuli in choice tasks did not influence microsaccade direction, however.

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Talks

High-level decision and emotion processes

Wednesday, August 14, 10:20 - 12:00

Room: Sångsalen

Chair: Philip Pärnamets

Changing minds by tracking eyes: Biasing moral decisions by interrupting gaze

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We argue that decision making is a dynamic process. Alternatives compete over time, and this competition plays out in sensorimotor processes, including eye movements. This is true not just for perceptual decisions or simple categorisation tasks, but also for moral decisions, which are the outcome of a complex interplay of intuition, emotion and reasoning. We report the results of a series of experiments investigating the role of eye movements in moral decisions. We first establish a descriptive and causal link between gaze and moral decisions showing that eye movements track decision processes and that decisions are sensitive to exposure times. We then use eye movements to track the time course of participants' moral decisions and show that by interrupting their decision process based on their gaze position, we are able to influence what they decide. We interpret this as evidence for a dynamical view of decision making and argue that our results provide new insights into how decisions are reached and constructed in our embodied minds.

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Visual attention in a complex task: discrimination of decisional processes with eyes movement patterns

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In complex tasks such as driving, visual attention is closely related to decision-making processes. For example, when approaching a crossroads, goal-directed processes are dominant and the driver needs to take fast decisions about Go/NoGo the crossroads. Driving is consequently a relevant task to study decisional processes using eye-movements. Under such activity, the decision-making is described with three cognitive processes possibly correlated to three oculomotor patterns. These processes are: information-taking (to collect information before the decision); control (after the decision); anticipation (information-taking attached to the next decision and control, depending on the risk level and the associated attentional resource). Road signs and traffic densities were manipulated in order to modulate the decision. We tested two hypotheses, one before and one after the Go/NoGo decision in the give-way condition: 1/ before the decision, oculomotor patterns are distinct between give-way (information-taking), stop (anticipation) and priority (control); 2/ after the decision, it was similar between priority and give-way with Go decision (control), and between stop and give-way with NoGo decision (anticipation). Thirty-four participants, equipped with an eye-tracker, drove in a simulator. Saccade amplitudes and fixation durations are in good agreement with our hypotheses. Finally, we focus on the dynamics of the processes.

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A walk on the wild side: Investigating attention during the consumer choice process in a real supermarket setting

Erik Wästlund, Lars Witell, Martin Löfgren, Poja Shams & Tobias Otterbring
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Several studies have investigated different facets of attention during the consumer choice process. Objectives have included how variation in attention changes throughout the choice process (Russo & Leclerc, 1994), its effect on preference formation (Shimojo et al 2003), the general distribution of attention (Wästlund et al, 2010), the effect of shelf placement (Chandon et al 2009), and the effect of a central placement on attention and choice (Atalay, 2010). The common drawback of these studies is that they are static lab experiments using digital images, which has been shown to influence gaze distribution (Tonkin et al, 2011). Therefore, in this study we use a head mounted eye-tracker to replicate previous research studies in a real retail environment to see if the results hold outside the lab. Data from 63 participants performing choice tasks in a supermarket are analysed. The results show support for a number of findings from previous research such as the initial central fixation bias and subsequent overrepresentation of observations of centrally placed products. Furthermore, the results support earlier findings on the general gaze distribution during the choice process but fail to replicate the strong effect of centrally placed products on choice. Additionally, methodological implications are discussed.

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Gender differences in attention to erotic print ads presented in a magazine context

Evgeniya Hristova & Stanislava Borisova
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Ads with erotic content are used to attract customers' attention. However, it remains unclear if there are gender differences in viewing such ads. There are also concerns that erotic models 'steal' too much attention and the rest of the information in the ad is not processed. To answer these questoins, male and female participants are presented with three versions of an erotic print ad (the erotic model is a single male, single female, or a male-female couple) in a between-subjects design. Participants browse a digitalized version of a magazine in which the ad appears (to get more ecologically valid data, participants are not instructed to pay attention to the ads). The preliminary results show that almost all participants notice the erotic ads, however, there are gender differences: women are attracted more by the ad depicting erotic couple, while men are attracted by the ad with the female erotic model. Attention to ads' elements (erotic model, brand) is also analyzed. For the erotic models the result is similar to the previous one: women pay more attention to the couple, men – to the female model. Almost all participants look at the erotic model, but only 60% of them notice the brand.

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Talks

Special symposium on Social gaze II

Wednesday, August 14, 13:30 - 15:30

Room: Stora salen

Chair: Tom Foulsham

Social Gaze: From Eyes to Lies

Tom Foulsham
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One method for studying social attention is to measure how participants attend to images of other people. The results of such experiments demonstrate that the eyes of other people are fixated early and often, and that this bias to select socially relevant information may lead to gaze following. Observers may also need to infer the person's thoughts and feelings about what they are looking at, but this has only rarely been investigated in laboratory studies. Moreover, when the stimulus is a real person—rather than merely an image—social gaze might serve a communicative function between interactants. After reviewing recent studies that measure social gaze during real interactions, I will present a novel laboratory paradigm that permits investigation of the two-way, communicative functions of gaze. Participants' eye movements were recorded during a preference task, and new observers were subsequently able to reliably guess the preference response by watching a replay of the fixations. When asked to mislead the person guessing, participants changed their looking behaviour and guessing success was reduced. These results confirm that people can spontaneously use the gaze of others to infer their judgements, but also that these inferences are open to deception.

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Eye gaze following during a face-to-face interaction

Megan Freeth
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The ability to accurately follow a social partner's eye gaze direction is an extremely important aspect of non-verbal communication. In infancy it helps us to learn the names of objects as social partners often look to objects they are talking about. In adulthood it can facilitate social communication as social partners tend to use eye gaze direction to indicate points of reference. Gaze following has been widely investigated using computer based paradigms where there is no social partner present but few investigations have been conducted on this ability during real life face-to-face interactions. Here I report a study investigating whether general patterns of eye movements during a social interaction, recorded using a mobile eye-tracking device, can predict the accuracy with which a participant can follow a social partner's direction of gaze. This study also investigated whether verbal ability, non-verbal ability or a participant's self-reported amount of autistic traits predicted their gaze following accuracy. Preliminary results indicate that verbal ability predicts gaze following accuracy. The relationship between general patterns of social attention, gaze following and autistic traits will be discussed.

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Following Multiple Gaze Cues in Social Scenes

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When faced with a social scene we tend to follow the gaze direction of an individual in the scene. However, little is known about how we respond when more than one person is present in a scene and providing directional gaze cues. We examined search behavior in real world scenes, with two individuals present, each gaze-cuing either the target object or a distractor within an array of 15 objects. Observers rarely fixated either individual's face and thus there was little overt gaze-following. Despite this, participants' search behaviour was influenced by the gaze cue direction. Gaze cues influenced both search initiation and scanning. The first saccade was more likely to be directed toward, and land closer to, the target when the target was cued by both subjects than when the subjects both looked at the distractor. Search efficiency was also greater when both subjects cued the target, with scan path ratios significantly closer to 1 in this condition. Gaze cues of multiple individuals appear to add, with greater search benefits when targets are cued by two individuals than by one individual. Thus responses are guided covertly by gaze cue information, even when these cues are not actively sought out.

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Gaze as a social tool: the case of depression and eye contact

Marie Saint Girons, Anitaz Mudali, Matthias Gobel & Daniel C. Richardson
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The eyes take in information about the physical world, but also, they are a tool to interact with the social world. This dual aspect of gaze is under-appreciated in theories and confounded in most experiments. For example, depressed people avoid looking into the eyes of others. This could be because they choose not to perceive information from the eyes, or because they signal their low self-esteem to others by avoiding eye contact. We present a paradigm that can distinguish these two functions of gaze. Participants watched videos of people talking into a camera. In one condition, they were led to believe it was a live video conference; in the other, that the videos were pre-recorded. Participants gazed more at the eyes of the higher status speakers across all conditions. But when they believed that they were part of a live social interaction, their depression scores interacted with gaze patterns. Depressed participants avoided the eyes when looking at people with high social status, but only when they thought that the person was looking back at them. We argue that this paradigm is a vital tool for distinguishing the social and the perceptual functions of gaze.

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Implied Social Presence of Conspecifics and Prosocial Behaviour

Alan Kingstone, Eleni Nasiopoulos & Evan Risko
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Animals often act in ways that are beneficial to conspecifics. While some causal factors are shared across species, others are unique to humans. For instance, people will behave in a more prosocial manner when the presence of other people is merely implied (e.g., security cameras). Importantly, what is unknown is whether this effect is short or long-lasting. Using an eye tracking camera, which promotes prosocial looking behaviour, we systematically investigated whether prosocial looking behaviour can be reduced or even eliminated without removing the inducing stimulus (i.e., the eye tracker). Our results demonstrate that the added experience of wearing the eye tracker can eliminate prosocial looking behaviour. This result carries both theoretical and methodological implications.

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Let's look at this together: The neural correlates of joint attention in social interaction

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In spite of its importance, the neural basis of joint attention is not well understood. In particular, functional magnetic resonance imaging (fMRI) studies have not been able to investigate differences in the neural correlates of joint attention depending upon joint attention being a result of gaze-following or being a result of directing someone else's gaze toward an aspect of the environment. We made use of an fMRI-compatible eyetracking setup, which allowed manipulating the gaze behaviour of a virtual character contingent upon the participant's gaze in real time. Using this setup, participants were engaged in interaction with the virtual other, which included leading and following the agent's gaze towards objects. Data analysis revealed activation of dorsal medial prefrontal cortex during joint attention. Furthermore, our analysis demonstrates recruitment of the ventral striatum, i.e. reward-related neurocircuitry, when participants are able to direct the virtual other's gaze toward an object. Consistently, participants indicated that they found joint attention to be more pleasant than looking at objects alone. These findings are in line with the idea that social interaction may prompt affiliative motives, the realisation of which is experienced as rewarding, relying upon an intrinsic motivation of humans for the sharing of experiences.

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Talks

Clinical research

Wednesday, August 14, 13:30 - 15:30

Room: Nya fest

Chair: Lo J. Bour

Eye tracking as a tool to diagnose visual processing impairments in children

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The number of children with visual information processing impairments, also known as cerebral visual impairment (CVI), is increasing. CVI is characterized by difficulties in perceiving various sorts of visual information, e.g. motion, color or form, depending on the brain areas that are affected. At the moment there is no strict definition of CVI, nor are there quantifiable test methods to diagnose CVI.

Recently, we showed that the quality of visual information processing can be assessed using remote eye tracking. This technique was based on (1) the presentation of specific sources of visual information (motion, form) that are known to be processed through separate channels in the brain and (2) measurement of orienting eye movement responses.

This method was applied in 104 children from 1-12 years attending special education for the visually impaired. We developed a new classification system for visual processing dysfunctions, based on orienting response time to specific visual features in predefined target areas. Children were divided into three groups (fast, medium, slow), according to the speed of their orienting response times. Orienting response times significantly depended on the type of stimulus. Children with relatively slow response times more often showed CVI characteristics than children with faster response times.

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Visual search for facial emotion in anxious patients: eye-tracking evidence for a therapeutic change

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Clinical studies showed that anxiety patients exhibit a differential pattern of enhanced bias towards emotional faces. We applied a face-in-the-crowd task with eye-tracking measurement to investigate a therapeutic change in the course of a psychotherapeutic outpatient group treatment. Anxious patients (APs, N = 26) were tested pre and post group psychotherapy (12 weeks apart); whereas healthy controls (HCs, N = 53) were tested once, on a face-in-the-crowd task using pictures of faces depicting angry, happy and neutral expressions. For both group a search asymmetry favoring happy faces was found, but APs were faster in detecting emotional faces among neutral crowd comparing to HCs. Interestingly, we found that in the posttest, the detection time (latency of the first saccade) for emotional faces got longer and there was a significant reduction of pupil dilation for angry faces, when compared to the pretest. Our data indicate a spatial processing bias for positive facial expression in both, clinical and nonclinical group. However, the bias was enhanced in the anxiety group. Further, this data suggest that clinical improvement can be accompanied by decrease in emotional reactivity indexed by changes in the eye-movement indices.

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Eye Movements Exhibited by Stroke Patients with Hemispatial Neglect: Why is Information Neglected?

Louise-Ann Leyland, Hayward J. Godwin, Valerie Benson & Simon P. Liversedge
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It has not yet been established whether hemispatial neglect results from an information sampling deficit or impaired processing of contralesional information during fixation. We recorded eye movements of acute neglect patients (NPs), stroke controls (SCs), and older adult controls (OACs) during visuo-motor tasks. Participants were required to cancel two different target letters presented amongst distractor letters (dual-target search) or clocks displaying a predetermined time amongst distractor clocks (single-target search). The NPs' poor target identification accuracy was restricted to contralesional regions but contralesional saccades were made to the same extent as controls. However, NPs spent less of the trial time fixating contralesional regions. This sampling deficit was exacerbated by increased task difficulty (i.e. dual-target search). Average contralesional gaze durations (sum of fixation durations before transgressing region boundaries) in the clock cancellation tasks were significantly inflated in NPs, indicating problems associated with either encoding or representing that information. The results not only reveal biased visual sampling in neglect, but also demonstrate that during contralesional fixations, disruption in processing was evident. These results have implications for the efficacy of interventions that shift involuntary eye movements into the neglected area, as even when NPs visually sample information, they may still fail to perceive it.

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Visual exploration of dynamic real-world scenes in patients with hemispatial neglect

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Visual exploration of everyday scenes requires attentional shifts performed by the use of saccadic eye movements. Patients with hemispatial neglect show deficits in exploring static scenes and in visual search paradigms using abstract stimuli. However, little is known about their scanning behaviour in moving real-world scenes. Since visual attention is largely driven by the salience of visual targets and motion is one of the strongest cues, we wondered whether neglect patients' exploratory eye movements differ between naturalistic dynamic and static scenes. Using a remote eye tracker at bedside, we examined 19 patients with spatial hemineglect following acute right hemisphere stroke, 14 right-brain damaged patients without neglect and 21 healthy control subjects. Real-world scenes were presented as static photographs, dynamic scenes and in a search context. We analyzed fixation distribution, saccadic amplitude, fixation duration and the impact of physical scene properties (motion, colour, contrast) on fixations. Results indicate that the pathological attentional rightward shift in neglect patients can be partially overcome by moving objects in the left hemifield. In visual search, left-sided targets were more likely to be found when they were moving. In the future, the use of modified real-world movies may be an interesting complement to current neglect therapies.

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Anti-saccades, scanning and smooth pursuit abnormalities in psychiatric disorders with deficiency of executive function

Lo J. Bour[1], Miriam Van Tricht[1], Odette Brand[2], Hans Koelman[1], Dorien Nieman[1] & Don Linszen[1]

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Several studies in patients with psychosis or patients who are at high risk for a psychosis (UHR) have demonstrated that eye movement abnormalities are related to a deficiency in executive function including difficulties in planning, organization, working memory and inhibitory control. The brain structure which is thought to be responsible for this deficiency is the dorsolateral prefrontal cortex.

First, compared to a healthy control group in schizophrenic patients and UHR patients a significant increase in anti-saccade error-rate, which is related to neuropsychological tests of poor spatial working memory function, has been demonstrated.

Secondly, evaluation of the visual scanpaths in schizophrenic patients demonstrated that compared to healthy control subjects they had shorter scanpath lengths and showed more staring behavior in detailed pictures, while focusing more on salient features of pictures. This deficit in visual scanning also seems to be related to impairement of executive functioning, particularly planning and imposing a strategy to visual scanning.

Finally, we have demonstrated that both the corrective and non-corrective saccadic rates during SPEM are higher in an UHR group, whereas SPEM gain still is not affected. This increase of saccadic intrusions during SPEM also may be due to a failure of saccadic inhibition by prefrontal structures.

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Reduced visual scene exploration in individuals with autism

Timothy Heaton & Megan Freeth
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Individuals with autism generally display heightened attention to detail, noticing aspects of their environment others may not. This "detail-focussed" processing style may be associated with atypical visual exploration. To investigate, we studied twenty four high functioning adolescents with autism and twenty four age and ability matched neurotypical adolescents viewing a series of static scenes for 5 seconds each and 15 seconds each.

Visual exploration was determined via the spread of fixation points over time and an evolving measure of the total explored image area was calculated using the convex hull of these points. On analysis, it was observed that participants with autism explored less of the scenes overall. Initially, participants with autism were seen to explore the scenes at the typical rate but later in viewing (3 seconds onwards) this exploration rate reduced. In contrast the neurotypical participants continued to explore the image at a relatively constant rate throughout the viewing period.

We suggest that the observed tendency to return to areas already inspected, rather than exploring new areas of scenes, in the individuals with autism may contribute to their heightened attention to detail.

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Talks

Co-registration with other measurements I

Wednesday, August 14, 13:30 - 15:30

Room: Lilla salen

Chair: Reinhold Kliegl

Fixation-related fMRI analysis in the domain of reading research: using self-paced eye movements as markers for hemodynamic brain responses during visual letter string processing

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The present study investigated the feasibility of using self-paced eye movements during reading (measured by an eye tracker) as markers for calculating hemodynamic brain responses measured by functional magnetic resonance imaging (fMRI). Specifically, we were interested in whether the fixation-related fMRI analysis approach was sensitive enough to detect activation differences between reading material (words and pseudowords) and non-reading material (line and unfamiliar Hebrew strings). Reliable reading-related activation was identified in left hemisphere superior temporal, middle temporal, and occipito-temporal regions including the visual word form area (VWFA). The results of the present study are encouraging insofar as fixation-related analysis could be used in future fMRI studies in order to clarify some of the inconsistent findings in the literature regarding the VWFA. Our study is the first step in investigating specific visual word recognition processes during self-paced natural sentence reading via simultaneous eye tracking and fMRI, thus aiming at an ecologically valid measurement of reading processes. We provided the proof of concept and methodological framework for the analysis of fixation-related fMRI activation in the domain of reading research.

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Measuring the neuronal correlates of reading using a novel spread spectrum technique

Ronan Reilly
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The aim of the research described here is to use a combination of eye tracking, EEG, and recent developments in signal processing to analyse the neuronal processes underlying word processing during a fixation in reading. A recently developed signal processing technique, VESPA, offers the possibility of measuring ERPs during free viewing. This is achieved by "tagging" different regions of interest, in this case words, using random luminance variation where these tags can be recovered through a simple convolution process in the subsequent ERP analysis. The ERP amplitude associated with each tag can then, in principle, tell us what word is being attended to at a given point during a fixation. The VESPA technique is applied to a reading-like task to decide between the alternatives of discrete attention shift and distributed attention gradient in the processing of words in a fixation. The results of the study indicate that the attentional gradient account is a better fit to the ERP data.

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Oscillatory brain dynamics differ between natural reading and serial presentation

Paul Metzner, Titus von der Malsburg, Shravan Vasishth & Frank Rösler
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Recent research (Dimigen et al., JEP:G, 2011; Kretzschmar et al., NeuroReport, 2009) shows that fixation-related potentials (FRPs) yield similar results as brain potentials recorded during rapid serial visual presentation (RSVP). We conducted an experiment to see if this correspondence also holds for oscillatory brain dynamics. Participants (N=48) read true ("The Thames flows through London") and false statements ("The Hudson flows through London"). Such violations are known to elicit an N400, a negative-going deflection with a peak around 400 ms, and increased theta and gamma activity (Hagoort, Science, 2004). As expected, we see an N400 in the FRP and increased fixation durations and regression rates in the eye movement record. Moreover, a cluster-permutation test (Maris & Oostenveld, J Neurosci Methods, 2007) for fixation-related power spectra shows synchronization in the delta range (1-3 Hz) and desynchronization in the upper alpha range (11-13 Hz) but no theta or gamma effects. This is at odds with prior findings and suggests that fixation-related oscillatory EEG changes are not fully comparable to those observed in RSVP. One reason for the diverging results may lie in different processing demands: In RSVP, readers must retrieve earlier parts of the sentence from memory because they cannot make regressions.

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Saccade guidance and visual encoding are associated with EEG activity in presaccadic interval

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Simultaneous analysis of eye movements and EEG enables us to investigate the processes of visual encoding in natural scene viewing and to distinguish them from the processes related to saccade guidance. We recorded eye movements and EEG in adult participants during free viewing of color photographs in anticipation of a change detection test. We measured the evoked potentials time-locked to saccade onset in the 200-ms presaccadic interval. Saccade guidance was evaluated by saccade directions on fixation heat maps. The amplitude of the evoked potentials was larger when the eyes moved from low to high heat areas on the map than in the opposite direction. This effect was observed for medium and long but not for short saccades. These findings suggest that amount of attention invested in selection of saccade targets depends on distance between the targets. Visual encoding was tested by correctness of subsequent change detection. Correctness was reflected in the amplitude of the potentials preceding long, but not medium or short saccades. We concluded that successful encoding depends on exploration of a visual of a scene in its entirety rather than on its details.

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Fixation-related potentials during scene perception

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Fixation-related potentials (FRPs), EEG voltage fluctuations time-locked to saccade offsets, are a promising technique to study neural correlates of attention and cognition under natural viewing conditions. While large and easy-to-measure signal components like P300/N400 have been replicated in FRPs, there is not yet a good understanding how various visual, extraretinal, and oculomotor factors influence the basic waveform. Goal of the present study was to model low-level influences on the dominant P1 component of FRPs during scene perception. Eye tracking and EEG recordings were combined while thirty participants searched for a randomly appearing target stimulus within photographs of natural scenes, phase-scrambled scenes, and in total darkness. A generalized additive mixed model uncovered various independent influences on P1 amplitude. We observed strong non-linear effects of the fixated screen location, most likely explained by relative movements of the slightly brighter monitor area across retinotopic cortex. This effect was similar for all pictures. Among the picture-specific significant predictors were local image luminance at the currently foveated spot, the absolute luminance difference to the previously foveated spot, lag and current fixation duration, and incoming saccade amplitude. Recordings in darkness also revealed small extraretinal contributions to FRPs. We discuss implications for free viewing experiments with EEG.

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Talks

Saccadic programming II

Wednesday, August 14, 13:30 - 15:30

Room: Sångsalen

Chair: Françoise Vitu-Thibault

All eyes on the center of gravity: Initial saccadic landing positions on peripherally-presented daily-life objects are largely explained by low-level factors

Lotje van der Linden & Françoise Vitu
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The purpose of the current study was to explore what determines where the eyes land on peripherally-presented isolated photographs of daily-life objects. Specifically, we investigated whether saccadic landing positions depend solely on low-level factors such as luminance contrast, or whether higher-level factors such as object affordances also play a role. Participants were instructed to make vertical saccades towards peripherally-presented graspable objects (e.g a spoon), and to categorise them with a left- or right-handed response. To investigate whether object affordances influence landing positions, the objects were rotated such that their handle pointed either towards the left or the right. In addition, we manipulated the contrast of either the left or the right side of the objects. Although visuomotor priming (an affordance effect of handle orientation on response times) was apparent from manual behaviour, this was not reflected in early eye-movement control: Initial saccades were not biased towards the action-related side of the object (nor towards the opposite side). Instead, landing positions could be fully explained by low-level effects: Participants' eyes landed near the center of gravity of the object, near the part of the object where the contrast was highest, and with the least possible deviation from the horizontal starting position.

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Parameters of catch-up saccades while tracking time-continuous transiently disappearing target

Raimondas Zemblys, Vincas Laurutis & Saulius Niauronis
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In this study intersaccadic intervals of successive catch-up saccades, performed before and after, or during and after the target occlusion onset was analysed. Oculomotor system is able to predict target motion up to 200ms and after this period of time, position error between target position and eyesight starts to increase. It was found that catch-up saccades are performed only up to 100ms after target occlusion onset and there are only 2.9% of saccades executed from 100 to 250ms after the target is occluded. This means that extraretinal components build from visible target motion, can drive smooth pursuit for a longer time than saccades. Information about target motion required to prepare a catch-up saccade is gathered during ongoing smooth pursuit. In case of target disappearance during ongoing saccade, successive saccade is performed with longer intersaccadic interval (250 – 400 ms) and therefore it probably belongs to "voluntary target search" saccades, not the regular catch-up saccades, which have intersaccadic interval of 100 – 200 ms.

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RAN Eye-movements Are Predictive of Reading Ability

Regina Henry[1], Victor Kuperman[1] & Julie Van Dyke[2]
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The rapid automatized naming task (RAN), which measures the time to name sequences of symbols arranged as a grid, is diagnostic of reading ability across ages and skill levels. The dominant view is that RAN is predictive of reading due to shared phonological components (Wolf & Bowers, 1999; Savage et al., 2007). We investigated whether predictivity stems from similarity in eye-movement patterns required by RAN and reading. We compared the eye-movements of 50 undergraduate students during text reading for comprehension, and completion of three RAN-type tasks. The critical task required visual silent inspection of grids with identical items (asterisks) and thus removed from the traditional RAN both articulation, and retrieval of symbol names from memory. For each participant, eye-movements recorded during asterisk-scanning explained 8-25% of variance in the average total fixation time, fixation count, skipping and regression rate observed in reading of coherent texts. This significantly exceeded the amount of variance explained by eye-movement measures registered in RAN tasks requiring phonological processing. We argue that RAN is predictive of reading skill partly due to a visuo-oculomotor component these tasks share: namely, the ability to repeatedly engage and disengage attention to visual stimuli as the eyes move through the text.

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The inter-trial spatial biases of stimuli and goals in saccadic programming

Jason Jeremy Sinclair Barton[1], Tara Rastgardani[1,2] & Mathias Abegg[1,3]
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Prior studies have shown an 'alternate antisaccade-goal bias', in that the endpoints of antisaccades are displaced towards the location of antisaccade goals used in other trials in the same experimental block. This paradigm can also be used to explore the persistent spatial effects of other aspects of the alternate trial. In different blocks we studied the alternate-trial biases generated by antisaccade goals, antisaccade stimuli, and prosaccades. We confirmed that alternate antisaccade goals generate an attractive bias regardless of whether the current trial is an antisaccade or a prosaccade. However, alternate antisaccade stimuli and alternate prosaccades generate a repulsive bias, greater for the former than the latter. These findings may reflect averaging of current and alternate trial activity in a salience map, in which alternate antisaccade goals contribute an excitatory spatial effect, while the repulsive bias from alternate prosaccades may be related to inhibition-of-return-like phenomena, which may be supplemented in the case of alternate antisaccade stimuli by additional inhibition at the stimulus location, in order to suppress reflexive saccade errors.

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Just Passing Through? Inhibition of Return in Saccadic Sequences

W. Joseph MacInnes, Hannah M. Krüger & Amelia R. Hunt
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Responses tend to be slower to previously attended spatial locations, an effect known as Inhibition of Return . The goal of the current study is to examine the role of saccadic sequence in IOR, namely, whether the recently-fixated location was the final target of a sequence, or it was a step along the way to that target. We tested both saccadic and manual responses by probing for IOR at intermediate locations along planned and unplanned saccade sequences. With saccadic responses, IOR was predominant when saccade sequences were unplanned and reduced for planned saccade sequences. Saccadic IOR was observed only when probes appeared soon after the saccade sequence. With manual responses to probes, IOR was present in both planned and unplanned sequences for late probe onsets. The results confirm that the characteristics of IOR depend critically on the response modality used for measuring it, with saccadic and manual responses giving rise to motor and attentional forms of IOR, respectively. Saccadic IOR is relatively short lived and reduced at intermediate locations of planned saccade sequences, while attentional IOR is long lasting and is consistent for all sequence types.

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Population averaging in the distorted map of the Superior Colliculus: A universal principle which accounts for where the eyes move in a variety of tasks

Françoise Vitu & Soazig Casteau
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In oculomotor, perceptual and reading tasks, saccades quite systematically move the eyes towards the center of peripheral stimuli, but they exhibit greater variability and a gradually more-pronounced center-undershoot tendency as stimuli become more eccentric. Here we show, in contrast with previous strategy-based accounts, that this rather-universal property of saccades reflects the distortion of visual space (or foveal magnification) in oculomotor-center maps. Four sets of eye-movement data, collected while participants either aimed at singleton-target stimuli or read series of words, were used. In all data sets, initial landing sites, when expressed in degrees of visual angle, exhibited both a larger spread and a greater center-undershoot tendency as stimuli became more eccentric. More interestingly, the distributions of initial landing positions, when converted in millimeters of collicular space, using Ottes et al.'s (1986) logarithmic mapping function of the Superior Colliculus (SC) in monkeys, were all perfectly centered on the stimulus collicular image and showed equal variability for the different stimulus eccentricities. Thus, irrespective of the task, neuronal activity likely builds up at the center of the stimulus pattern in collicular space, probably as a result of population averaging. However, due to non-homogeneous afferent/efferent mapping, saccades are inevitably, slightly biased towards the fovea.

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Talks

Scene perception

Thursday, August 15, 10:20 - 12:00

Room: Stora salen

Chair: Monica S. Castelhano

Statistical modeling of the influence of a visual distractor on the following eye-fixations

Hélène Queste, Nathalie Guyader & Anne Guerin-Dugue
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We examined the influence of a visual distractor appearing during a fixation on the following fixations during natural exploration. It is known that new objects, congruent or incongruent with the scene, appearing during a fixation are fixated more than chance [Brockmole, J. R., & Henderson, J. M. (2008). Prioritizing new objects for eye fixation in real-world scenes: Effects of object-scene consistency. Vis. Cog., 16(2-3), 375-390]. In this study, we replicated this result using a Gabor patch for the appearing object, called a distractor because it was artificial and non-related to scenes. Besides, we wanted to quantify its influence on the exploration. A statistical model of the fixation density function was designed to analyze how the exploration was disrupted from and after the onset of the distractor. The model was composed of a linear weighted combination of different maps modeling three independent factors influencing gaze positions. We wondered whether fixation locations observed were rather due to the distractor or the saliency of the scenes. As expected, at the beginning of the exploration, fixation locations were not randomly chosen but influenced by the saliency of the scene and the distractor. The distractor onset strongly influenced fixations and this influence decreased with time.

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Task-dependent priming of fixations during recognition of natural scenes

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Fixations allow perceiving scene content with high acuity. If fixations drive visual memory for scenes, a viewer might repeat his/her previous fixation pattern during recognition. However, visual salience alone could account for any similarities between two successive fixation patterns by attracting the eyes in a stimulus-driven, task-independent manner. In our eye-tracking experiments we tested whether the viewer's aim to recognize a scene fosters fixations on details that repeat from learning to recognition. Furthermore, we checked whether task-related re-fixations outweigh the influence of stimulus-driven salience. We found that during recognition but not during (repeated) free-viewing our participants showed a pronounced preference for previously fixated details. We also investigated whether participants remembered visual input fixated during learning better than salient but nonfixated visual input. To that end we presented participants with smaller cutouts from scenes. Previously fixated cutouts from learned scenes were discriminated from novel, hitherto not presented cutouts better and faster than nonfixated but highly salient cutouts from learned scenes. Our experiments support the hypothesis that fixations during encoding (and maybe during recognition) serve visual memory over and above a stimulus-driven influence of visual salience. We will discuss our results with regard to research on priming of visual search.

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Semantic Mapping of Point-of-regard and Saliency in Automatically Acquired 3D Models of Indoor Environments

Lucas Paletta, Katrin Santner, Gerald Fritz, Albert Hofmann, Georg Thallinger & Heinz Mayer
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This work describes the estimation of localisation and orientation of human gaze with respect to indoor environments, without the need of artificial landmarks in the field of view, and being capable of accumulation for saliency mapping. In contrast to previous work (Vosskühler, 2009, Proc. ECEM; Takemura et al., 2010, ETRA; Pirri et al., 2011, Proc. CVPR), our methodology enables mapping of fixations directly into an automatically computed 3D model of the environment. We firstly built a spatial reference using RGB-D SLAM methodology (Pirker et al., 2011, Proc. BMVC). 3D volumes were automatically annotated from mapped visual ROI appearances that were localised in a geo-referenced video stream with descriptor matching (Lowe, 2004, IJCV). The user's view is gathered with wearable eye tracking glasses and localized from extracted local descriptors (Nister & Stewenius, 2006, Proc. CVPR). Our study reports full 3D recovery of the view frustum and the gaze pointer with an accuracy of ≈1.1 cm in near range distances of 1-3 m. The distribution of saliency onto the 3D environment is computed for further human attention analysis, such as, evaluation of the attention mapping with respect to object and scene awareness, derived from an ROI based semantic annotation process.

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What can Fixation Duration Tell Us about Scene Viewing?

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When and where we move our eyes are the fundamental questions for eye movement research, which have been extensively studied in reading. However, in scene viewing studies, fixation duration data are usually neglected. In analogy to reading studies, the present study categorizes fixations into first fixation duration (FFD), gaze duration (GD), and total time (TT) for various eye-movement datasets for a fixated region. The results indicate that fixation durations are influenced by task instruction, scanning strategy for a given viewing time, and foveal processing. Taken together, this study introduces interdisciplinary methods to blur the boundary between reading and scene viewing for visual information retrieval and the underlying cognitive processing.

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Examining the influence of image features, visuomotor parameters, and task set on fixation durations in scene viewing

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Scene perception requires the orchestration of visuospatial, image-related, task-related, and oculomotor processing constraints. The present study investigated how these factors influence how long the eyes remain fixated in a given location. Specifically, we tested whether local image statistics (including luminance, luminance contrast, edge density, visual clutter, and mean-shift segmentation), calculated for 1° circular regions around fixation locations, modulate fixation duration and how these effects depend on task-related control. Fixation durations and locations were recorded from 72 participants, each viewing 135 scenes under three different viewing instructions (scene search, memorization, preference judgment). Along with the image-related predictors, linear mixed models simultaneously considered a number of visuomotor and spatio-temporal covariates, including the amplitude of the previous and next saccades, and viewing time. As a key finding, local image statistics around the current fixation (n) predict this fixation's duration, irrespective of viewing task. For instance, greater luminance is associated with shorter fixation durations. Corresponding distributed-processing analyses investigate effects of these variables related to previous (n - 1) and next (n + 1) fixation locations. The results are in general agreement with the CRISP model of fixation durations, proposing that difficulty in moment-by-moment visual and cognitive processing of the scene modulates fixation durations.

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Talks

Aging and neurodegeneration

Thursday, August 15, 10:20 - 12:00

Room: Nya fest

Chair: Andreas Sprenger

Inherited Metabolic Disease: Measuring Cognitive Effects Using Eye Movements

James Michael Blundell[1], Shauna Kearney[2], Andrew Olson[1], Steven Frisson[1], Suresh Vijay[2], Anupam Chakrapani[2], Paul Giseen[3] & Chris Hendriksz[4]

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Lysosomal storage disorders are heterogeneous inherited metabolic disorders caused by dysfunctional lysosomal enzymes. Consequentially, the build-up of molecules leads to progressive cell damage and mental deterioration. Across these disorders, the evaluation of cognitive function using standardised measures is complicated by heterogeneity in clinical presentation. Thus, little is known about neuropsychological profiles of these disorders.

The system for controlling eye-movements is a finely tuned and specialised motor system which communicates very efficiently with systems that are responsible for attention, executive function and language. In addition, eye movement tasks are relatively natural for children to participate in, making them potentially useful for measuring the effectiveness of promising new treatments.

In the current study we record the eye movements of a group of children diagnosed with Morquio syndrome (MPS IVa), a disorder associated with mild attentional difficulties. We used three oculomotor tasks: a fixation task, and a pro- and anti-saccade task.

Patients show clear problems with some of these tasks. For example, patients have difficulty maintaining fixation and inhibiting eye movements during the fixation task. In contrast, patients' pro-saccade performance is unaffected. We show that eye movements provide a sensitive and selective measure for measuring the cognitive effects of metabolic diseases.

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Testing of predictability effect during reading in patients with probable Alzheimer disease.

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Studies measuring how patients with probable Alzheimer disease process well defined words in high and low predictability sentences are, at our knowledge, inexistent. In the present study we examined eye movement behavior during reading of 18 AD versus 40 age-matched Control using the eyetracking technique. Independently of what kind of sentence they were reading, AD did not report a differentiated processing relating to upcoming words. Quite the contrary, incoming word predictions influenced fixation duration in Control and as consequence they showed a well differentiated word processing during reading high predictability sentences. In AD, visual exploration was less focused; fixations were much longer and saccade amplitudes were smaller than in Control. Our results suggest that the altered visual exploration and the absence of word predictability effects might be related to impairments in working memory, memory retrieval, and semantic memory functions. These eye movement measures demonstrate considerable sensitivity with respect to evaluating cognitive processes in a early stage of AD.

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Non-uniform velocity gain in the head impulse test: a study of healthy controls and patients with SCA-3

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Spinocerebellar Ataxia Type 3 (SCA-3), also known as Machado-Joseph Disease (MJD), is an autosomal dominant neurodegenerative disorder that, among its other symptoms, affects the vestibulo-ocular reflex (VOR). The head impulse test (HIT) measures the response of the VOR to abrupt head rotations. In this test, the clinician manually rotates the subject's head for approximately 100 ms with a high acceleration. The head's motion is composed of an acceleration phase prior to the peak velocity followed by a deceleration phase. We measured eye and head position using a magnetic search coil and then calculated velocity gain during specific time windows of the head's motion. Results for healthy controls showed that velocity gains during the second part, the deceleration phase, were significantly higher than the gains during the first part, the acceleration phase. Thus, the higher gains in the second phase compensate for the relatively low gains in the first phase. While some SCA-3 patients showed normal velocity gain during the acceleration part, even they had impaired gains in the deceleration phase. Thus, all SCA-3 have impaired velocity gains in the HIT, demonstrating that it is essential to evaluate the gains in the deceleration phase.

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Insight into the increased risk of falls in older adults: age-related changes in gaze behavior and biomechanics during obstacle, step and stair negotiation

Kate Hamel, Nicole Mueske & Kari Loverro
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Age-related changes in visual function have been linked to decrements in functional mobility and an increased risk of falls in older adults. Despite this knowledge, we know little about how older adults use visual input to negotiate challenging terrain. Tripping over obstacles, steps or stairs accounts for a large proportion of falls in older adults, and may be linked to inadequate or aberrant visual input. The purpose of this study was to characterize the age-related differences in temporal and spatial coupling of gaze behavior with motor output during obstacle, step and stair negotiation. Gaze behavior and 3D whole body kinematics were collected on ten young (25±3 yrs) and seven older (75±5 yrs) adults. During obstacle and single step negotiation, older adults utilized what appeared to be a riskier gaze behavior strategy – shorter obstacle and step fixation times, earlier gaze transfer away from the obstacle or step and a greater portion of travel time spent shifting their gaze compared to young adults ($p<.05$). Preliminary results from stair negotiation suggest that older adults utilized a different and possibly safer strategy on stairs with total stair fixation times equal to (stair ascent) or longer than (stair descent) the young adults.

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Prediction and anticipation in the smooth pursuit system: potential mechanisms to modify performance decline with increasing age or motor system diseases

Andreas Sprenger[1], Jonas Pohlmann[1], Peter Trillenberg[1], Rebekka Lencer[2] & Christoph Helmchen[1]
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Externally guided sensory-motor processes are used to follow smoothly moving objects. Internally guided, for example predictive, behavior usually helps to overcome sensory-motor delays which may occur with age or disease. Parkinson's disease (PD) is associated with impairment of self-guided movements. Controversy surrounds the question whether age- or disease-related decline in sensorimotor transformation can be compensated by higher level mechanisms. Pursuit performance is supported by anticipation of oncoming target motion and – while tracking an object – prediction of future motion. To dissociate between these two components we used target blanking paradigms in PD patients and a larger cohort of healthy controls. Compared to controls PD patients showed (i) decreased smooth pursuit gain, (ii) deficient anticipatory pursuit, and (iii) preserved extra-retinal predictive pursuit velocity. In healthy controls basic motor performance declines with age but anticipation and prediction are still present in old age: non-predictive pursuit performance significantly deteriorates with increasing age whereas predictive pursuit performance does not. PD patients showed intact predictive mechanisms but exhibited difficulties in anticipating future target motion which plays a crucial role in gait initiation and termination. To conclude: prediction and anticipation (if still present) can be used to modify age- or disease-related decline in motor performance.

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Talks

Educational psychology II

Thursday, August 15, 10:20 - 12:00

Room: Lilla salen

Chair: Eduardo Santos Junqueira

Tracking eye movement in solving geometry problems

John Jr-Hung Lin & Sunny S. J. Lin
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The study investigates: (a) whether eye movement patterns are different between successful solvers and unsuccessful solvers and (b) whether eye movement is sensitive to perceived difficulty (measured by a cognitive load scale). Fifty seven 11th graders solved five geometry problems selected from the previous experiment. Participants used a digital drawing tablet and sensitive pressure pen to calculate and input answers. The result indicates more duration and fixation points on question area but less on answer area as the problem becomes difficult. Unsuccessful solvers gain more dwell time and fixation count on question area but less on answer area. Moreover, unsuccessful solvers have more regressive behavior in question area. In sum, difficult problems would make participants pay more attention to question area instead of answer area. Besides, fixation count and dwell time of both problem and answer areas are sensitive to the changes of difficulty only when problems are difficult (pass rate= .37) and run count within the problem areas is sensitive to the change of difficulty as well. In this study, the findings suggest some sensitive eye movement indicators and eye movement approach are quite promising for future research on researches of on-line cognitive processes.

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There's more to multimedia than meets the eye: is seeing pictures believing?

Halszka Jarodzka[1], Marcus Nyström[2] & Magnus Ögren[3]
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Cognitive theories on learning with multimedia recommend combining different presentation formats (e.g., text and pictures) in teaching. However, recent research showed that pictures lurk people into trusting the accompanying text, instead of critically studying it. To investigate this we asked 36 physics students to solve mathematical problems, which consisted of a text describing the problem and a statement about the problem that had to be confirmed or rejected (control). The multimedia condition additionally received graphs displaying the same information as the text. Results revealed a bias to confirm statements that were accompanied by a graph – irrespective of their correctness. Eye tracking showed that students looked less at the text and the problem statement when a graph was present. The more students looked at the statement and the more transitions they made between the statement and the graph, the better they performed. Verbal data showed that students heavily relied on the graphs: when the graph itself was correct, but the statement was not, students judged the statement as correct referring to the graph. Thus, the mere presence of pictures is not sufficient. Instead, they need to be carefully integrated with the problem statement to improve performance.

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Viewing Behavior during Multimedia Learning: Can Eye Tracking Measures Predict Learning Success?

Carina Schubert, Katharina Scheiter & Anne Schueler
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This study uses eye tracking to identify different patterns of viewing behavior and their relevance for learning outcomes. Twenty-nine students completed a multimedia learning session while their gaze movements were recorded. Learning outcomes were assessed afterwards. To investigate the cognitive processes associated with viewing behavior, we also collected verbal data with cued retrospective reporting: Learners were shown a low-speed gaze replay of their own learning session and instructed to comment on their eye movements. Total fixation durations on text and pictures and count of transitions between both representations were entered into a cluster analysis that identified three clusters of viewing behavior. One cluster of learners showed strategic viewing behavior with high values on all indicators, resulting in good learning outcome. A second cluster was characterized by lower values on all parameters and poorer learning outcome. Interestingly, the third cluster showed a processing behavior that was quite similar to that of the first cluster except for even longer processing of text, but had poorer learning outcomes nevertheless. These findings suggest that different processing strategies of multimedia material as indicated by learners' viewing behavior influence learning success. Verbal data is still under analysis but will be presented at the conference.

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The effects of information presentation mode, textual and graphic complexity on science learning in a self-paced learning scenario

Ying-Hua Guan
National Taiwan Normal University, Taiwan, Republic of China

This study examined how information presentation modes (texts+graphics vs. narration+graphics vs. texts+narration+graphics), textual and graphic complexities affect students' allocation of attention to the instructional materials during learning. Students' eye movements were observed when they were studying four learning units about astronomy on computer. The result of students' learning-efficiency index contradicted the modality effect but confirmed the redundancy effect with the audio-visual format of information being less efficient than the visual-only one.

It was found that the mean fixation duration in the graphics was significantly higher when the learning materials were presented by narration and graphics, which points to divided attention between narration and graphics. Furthermore, students receiving graphics with texts and narration simultaneously read texts significantly slower than those who received graphics with texts, indicating an interference caused by the redundant information from texts and narration. Finally, the complexity of texts and graphics and their interactions guided students' attention. When texts were complex, subjects proportionally devoted less time reading texts than when they were easy. When graphics were complex, subjects spent more time viewing graphics than when they were easy. However, when both texts and graphics were complex, proportionally more time was devoted to texts rather than to graphics.

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How a Picture Fosters Comprehension of Text: Evidence from Eye Movements on Blank Screen

Alexander Eitel[1], Katharina Scheiter[1], Anne Schüler[1], Marcus Nyström[2] & Kenneth Holmqvist[2]
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The present experiment investigated how processing a picture affects comprehension of text. It was hypothesized that both brief and self-paced picture inspection would foster comprehension, because global spatial information would be rapidly extracted from the picture and reactivated as a mental scaffold to facilitate processing of text (scaffolding hypothesis). To test the scaffolding hypothesis, students (N=84) learned about the structure and functions of pulley systems from text or from text with previous presentation of a picture for 600ms, 2sec, or self-paced. Students' eye movements on blank screen while listening to text as well as their comprehension scores for the pulley system's functions were analyzed. Results revealed that in conditions with initial picture inspection (for 600ms, 2sec, and self-paced) more eye movements in line with the picture's global spatial orientation were made while listening to text and looking at a blank screen. Moreover, comprehension of the pulley system's functions was better in conditions with initial picture inspection (for 600ms, 2sec, and self-paced) than in the text-only condition. Results thus suggest that global spatial information extracted from brief and self-paced picture inspection was reactivated while processing text to support comprehension, yielding support for the scaffolding hypothesis.

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Talks

Sound and phonology

Thursday, August 15, 10:20 - 12:00

Room: Sångsalen

Chair: Thierry Baccino

Effects of music and visuo-spatial layout on attention during reading Investigated with eye tracking

Thierry Baccino & Véronique Drai-Zerbib
LUTIN-CHART Paris 8, France

In the present study, we compared musicians and non-musicians' text reading comprehension in 6 conditions. 34 Participants read 30 multiple topic expository texts while listening concurrently lyric music, instrumental music, or in silence. 15 texts were presented with a semantic layout and 15 without any. After reading each text, participants answered two multiple-choice questions. Eye movement data were recorded over the experiment. Results showed that musical environment impacted reading but musicians were less affected than non-musicians. Global analysis of texts indicated a number and duration of fixations significantly higher in lyric condition. Analysis by sentences (Area of Interest) showed a facilitatory effect of layout in the fixations durations and longer fixation durations in lyric listening compared to instrumental listening or silence. Longer fixation durations in lyric condition were more important at the beginning of the reading and predominantly for non-musicians. It appears that listening lyric music while reading engages an overlap of verbal material processing. However this high demanding cross modal task affects mainly non-musicians. These findings are discussed in terms of attention multiple resource model (Wickens, 1984).

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Eye movement study of oral and silent reading performance

Gustaf Öqvist Seimyr
Karolinska Institutet, Sweden

Reading performance is commonly assessed by oral tests. Yet, are such results really indicative of silent reading performance? In this talk I present findings from a balanced repeated-measurement study where 32 subjects read texts aloud and quietly. Reading performance was evaluated in terms of reading speed and comprehension; moreover task load and subjective experience was assessed. Eye movements were recorded and analysed in terms of fixations and saccades. The results show that oral reading decreased reading speed whereas comprehension increased. There were no significant differences in task load, but oral reading decreased the experience of comfort and naturalness. The number of fixations per word and the average durations were higher in oral reading. Progressive and regressive saccades were more common and shorter in oral reading; there was no difference in the ratio between modes. Interestingly, the correlation between oral and silent reading speed was only moderately positive, whereas the correlation between oral and silent reading comprehension was even weakly negative. This shows that oral reading performance is not necessarily a good indication of silent reading performance; it may even point in the wrong direction. Tests performed silently are more likely to give a true assessment of how we usually read.

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Exploration of dynamic natural scenes: influence of unrelated soundtracks on eye movements

Antoine Coutrot & Nathalie Guyader
Gipsa-lab - CNRS UMR 5216 - Grenoble University, France

When exploring audio-visual scenes, our brain integrates information from both modalities. So far, attempts to understand audio-visual integration mostly used artificial stimuli. In a previous study, we showed that removing the soundtrack of natural dynamic scenes impacts on their exploration [Coutrot, A. et al. (2012). Influence of soundtrack on eye movements during video exploration. Journal of Eye Movement Research, 5(4)]. Here, we refine this work by studying the effect of a specific auditory scene on the exploration of a specific visual scene. We built a database of 45 videos split into 3 visual classes (Faces, Moving Objects and Landscapes). We eye-tracked 60 participants viewing each video in one of the following conditions: with its original soundtrack (Speech for Faces, Object Noises for Moving Objects, Environmental Noises for Landscapes); with a soundtrack of a video belonging to the same visual class; with a soundtrack of a video belonging to another visual class. We show that for Moving Objects and Landscapes, changing the auditory condition does not have a significant effect on eye movements. For Faces, we observe significant differences between the "original soundtrack" condition and the other auditory conditions. This might traduce the cognitive specificity of speech perception.

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Disambiguating Arabic Homographic Verbs during Reading

Ehab W. Hermena[1], Denis Drieghe[1], Sam Hellmuth[2] & Simon P. Liversedge[1]
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Arabic vowel sounds are conveyed by diacritics, which allow for accurate word pronunciation. Predominantly, modern Arabic is printed without diacritics. Readers typically use context to disambiguate homographs, with diacritics assigned to otherwise ambiguous words. We investigated the time course and effects of accessing diacritics-based phonology to disambiguate homographic verbs which are heterophonic in active compared to passive voice (e.g. ضرب /daraba/, hit; ضرب /doriba/, was hit). We tracked the eye movements of 25 native Arabic readers while reading these sentences in 5 conditions: active, or passive, fully- or non-diacritised, or with verb-only diacritisation in passive. Without diacritics on the verb, readers would not be able to discriminate the passive voice from the active until they reach a prepositional phrase (one word e.g. بيد /bijad/, by the hand of) later in the sentence. Results will be discussed detailing the impact of verb-only and full sentence diacritisation, including evidence that readers effectively extracted the phonological information conveyed by diacritics on the verb: Early looking times on the disambiguating region were significantly reduced in the verb-only diacritisation condition. By accessing passive verb phonology, the readers avoided mis-parsing the verb as active (which, in all likelihood, is their default parsing preference).

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Musicians' Long Term Working Memory cues and Multimodal integration investigated with Eye tracking

Véronique Drai-Zerbib & Thierry Baccino
LUTIN-CHART Paris 8, France

During many years of extensive practice, musicians shape their cognitive system to fluently read and play music. Most experts can hear music they are reading from the score before playing it on their instrument. Does the expertise in music rely on an efficient cross-modal integration using auditory and visual cues? The study investigates this issue with an eye-tracking experiment. Two groups of musicians (experts and non-experts) were required to report whether two musical fragments of classical music successively presented on a computer screen in a cross-modal presentation were same or different. An accent mark placed on a note, contributing to the prosody of the musical phrase, was put in a congruent or incongruent way, during the auditory and reading phases. The analysis of fixations and errors validated the cross-modal ability of musicians' expert memory. Experts spent more time for detecting a modification of note when the accent mark was incongruent during listening and congruent during reading. Experts were more able to localize the measure on which the modification occurred. This speed accuracy tradeoff was not available for non-expert musicians. An incongruent accent mark, not matching with usual musical structural rules can be a retrieval cue in memory for experts.

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Talks

Data quality

Thursday, August 15, 14:30 - 15:50

Room: Stora salen

Chair: Jeff B. Pelz

A Signal Detection Theory Approach to Characterize Oculometer Data

Kara Latorella[1], William Lynn III[1], Lon Kelly[2], Ming-Yun Shih[2], Dennis Frasca[2], Charles T. Feigh[2], Omar Scott[2] & Julie Timmons[2]
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Currently, data quality is described in terms of spatial and temporal accuracy and precision [Holmqvist et al. in press]. While this approach provides precise errors in pixels, or visual angle, often experiments are more concerned with whether subjects' Points of Gaze (POGs) can be said to be reliable with respect to experimentally-relevant areas of interest (AOIs). This paper proposes a method to characterize oculometer data using Signal Detection Theory (SDT) [Marcum 1947]. SDT classification results in four cases: Hit (signal is reported), Miss (no signal reported), False Alarm (signal falsely reported), Correct Reject (absence of a signal is correctly reported). Subjects are directed to look at points in and outside of an AOI, and the resulting POG are classified as Hits (points known to be internal to an AOI are classified as such), Misses (AOI points are not indicated as such), False Alarms (points external to AOIs are indicated as in the AOI), Correct Reject (points external to the AOI are indicated as such). SDT metrics describe performance in terms of discriminability, sensitivity, and specificity. This paper presentation will provide the procedure for conducting this assessment and an example of data collected for AOIs in a simulated flight deck environment.

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A Method to Measure the System Latency of Gaze-Contingent Displays

Russell L. Woods & Daniel R. Saunders
Schepens Eye Research Institute, United States of America

The appearance of gaze-contingent visual displays are rapidly and (often) continuously updated based upon information about where the observer is looking. All such systems have a delay, the system latency, between a change in gaze location and the related change in the display. Those delays can include computation of gaze from tracker information, filtering, transmission to the display computer, rendering of the updated image, transmission to the display, display lag, the refresh cycle and location on the display. We present a direct, simple and low-cost method to measure this system latency. The technique uses a device to briefly blind the eye tracker system (e.g. for video eye trackers, using infrared LEDs), creating an eye tracker event that triggers a change to the display monitor. The time between these two events, as captured by a relatively low-cost consumer camera with high-speed capability (1,000 Hz video), is an accurate measurement of the system latency. The same approach can be used to synchronize the eye-tracking time series and a video recording of the display. We present system latency assessments for several popular types of display.

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Pupil size under different lighting sources and evaluation of measurement uncertainty

Laura Rossi[1], Giuseppe Rossi[2] & Ludovico Zegna[3]
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The objective of this work is to monitor the effects of light on pupil size considering different type of sources and retinal images in order to isolate the effect of dimension and spectra distribution of the emitted radiations.

A pupillometric system has been built, constituted by an infrared illuminator and a high-resolution camera, in order to acquire eye images and get pupil dimensions through an ad hoc designed software.

From the first tests differences on pupil size due to different spectrum and shape of sources has been founded even at equal luminance of the source. This study, as a basic research on measurements of photobiological effects of light, would improve the knowledge of human visual system especially for applications in lighting design like road lighting or where psychophysical effects of light are important issues.

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Head motion compensation for remote eye tracker

Dong Wang[1], Anne Haake[1], Sol Simpson[2] & Jeff Pelz[1]
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Video based remote eye tracking is a non-intrusive eye gaze estimation technology. To allow free head movements, remote trackers attempt to compensate for head-screen distance variation during gaze tracking. In this study, we found that in addition to head position, head velocity is also a factor in the accuracy of gaze estimation for a current remote eye tracker. We also present a method to compensate for the velocity dependent degradation. To develop the approach, participants were instructed to move their head along the axis normal to the tracker display at different speeds while fixating predefined targets. Eye tracking accuracy was measured as the distance between the estimated gaze location and the intended fixation point. The ground-truth head position was obtained using a magnetic-field motion tracker with sub-millimeter accuracy. Preliminary results show that while the mean error of the eye tracker estimated head position was relatively small (<1% of the actual distance) there was significant variability in the measure (SD = 7.1% of the head-screen distance). We found a positive correlation between the vertical tracking error and head velocity. We propose a method to compensate for the errors that resulted in an average improvement in eye tracking data accuracy of 28.7%.

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Talks

Co-registration with other measurements II

Thursday, August 15, 14:30 - 15:50

Room: Nya fest

Chair: Jaana Simola

Comparison of changes in EEG frequency band power and in pupil diameter as measures of cognitive load during working memory and text reading tasks

Christian Scharinger, Yvonne Kammerer & Peter Gerjets
Knowledge Media Research Center, Germany

Research in the field of working memory (e.g., Klimesch, 1999) or neuroergonomics (Gevins & Smith, 2003) revealed that an increase in cognitive load (CL) leads to an increase in EEG theta-band power at frontal-midline electrodes and a decrease in alpha-band power at parietal-occipital electrodes. Pupil dilation also has a certain tradition as measure of CL in working memory (WM) and reading research (e.g., Beatty & Lucero-Wagoner, 2000). We were interested in a direct comparison of the sensitivity of changes in EEG frequency band power versus pupil dilation as measures of CL, using a working memory task with subtle manipulations of executive functions and a reading task that consisted of normal reading and hyperlink-based word selection processes. The WM task was a modified n-back paradigm incorporating a task-shift manipulation. The reading task was a modified German reading comprehension task with hyperlink-like words to be selected. Changes in EEG alpha frequency band power and in pupil diameter turned out to be valid measures of CL changes in both tasks, with the EEG measure yielding higher effect sizes. Interestingly, the amount of change in these two measures for increasing CL was not significantly correlated. We will discuss these findings in detail.

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Combined ERP and eye-tracking reveals the order of attentional and task-set reconfiguration

Cai Stephen Longman, Heike Elchlepp, Aureliu Lavric & Stephen Monsell
University of Exeter, United Kingdom

Switching tasks results in a performance overhead - the 'switch cost', believed to reflect (in part) the need for 'task-set reconfiguration' (TSR), which is endogenous (top-down) and time-consuming. Theoretical accounts of task-set control assume TSR is multi-componential, but the identity, order and timing of constituent processes is debated. Parallel models assume all task-set components are reconfigured concurrently, while serial models assume sequential TSR. We conducted a task-switching experiment in which brain potentials and eye-movements were recorded simultaneously. A well-documented ERP component associated with preparing for a switch is the switch-induced positivity in the late part of the (pre-stimulus) preparation interval – from 400-500 ms following onset of the task cue. Our lab has also documented a switch-induced delay in fixating the task-relevant region, indicative of the need to re-orient attention on switch trials. Here we aimed to determine the relative timing of the ERP switch-related positivity and attentional re-orienting, indexed by the first fixation 'landing' on the task-relevant region. Analyses of ERPs and landing time distributions showed that re-orienting attention always preceded the onset of the ERP positivity. This supports a bi-/multi stage model of TSR and suggests that attentional re-orientation occurs before other reconfiguration processes reflected by the positivity.

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Reducing ocular artifacts in EEG via eye monitoring

Jason Satel, Cameron D. Hassall, Olave E. Krigolson & Raymond M. Klein
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To examine the brain responses associated with specific behavioral processes, researchers record brain activity using EEG. Since eye movements and blinks generate large electrical signals that contaminate EEG, methods have been developed to deal with these artifacts. Electrooculography uses activity from electrodes near the eyes to identify and remove trials with eye movements, reducing signal quality or increasing the number of participants required. Mathematical techniques allegedly remove eye movement activity, but it is unclear whether all such activity is removed while leaving the neural activity of interest unaltered. This approach also necessarily includes trials with eye movements, often contrary to task requirements. Our recent experiments combining eye tracking and EEG demonstrated the potential of using eye tracking to increase EEG data quality. We used cueing tasks where participants maintained fixation, ignored or made eye movements to uninformative cues, then made manual localization responses to targets. Eye tracking and online feedback ensured appropriate oculomotor behavior at all times. The data was much cleaner than that obtained without concurrent eye tracking, suggesting that either participants learn to learn to control their oculomotor behavior through online feedback, and/or eye monitoring allows more accurate categorization of trials to be excluded than traditional techniques.

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Eye fixation related potentials during free viewing of natural scenes

Jaana Simola[1], Jari Torniainen[1], Jyrki P. Mäkelä[2] & Christina M. Krause[1]

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Humans actively examine the visual world by making saccades over the elements of the scene. Between the saccades, fixations provide the visual system with 100-400 ms to detect and recognize objects in the scene. We recorded eye movements and EEG simultaneously from 24 volunteers while they were viewing images of natural scenes. The stimuli consisted of 70 black and white nature photographs taken from the DOVES dataset, overlaid with a 4x4 grid. For each photograph, a single grid element was selected as a target image. The target image was shown first for 4 s, followed by the presentation of the natural image for 8 s. Next, the participants were asked to indicate whether the target image was part of the original image. To detect the time-course of the neural activity during the visual search task in natural scenes, the EEG responses were time locked to the pre-target, target and post-target fixations. The eye-fixation related potentials (EFRPs) recorded at the occipital sites demonstrated the typical Lambda response, peaking around 80 ms after fixation onset. Subsequently, the processing of the target-elements in natural scenes elicited a negative response at the occipital site at 200-300 ms after fixation onset.

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Talks

Language-related processes in reading I

Thursday, August 15, 14:30 - 15:50

Room: Lilla salen

Chair: Wayne Stuart Murray

Parafoveal pre-processing of word-initial trigrams during sentence reading: Evidence for flexible coding

Ascension Pagan, Hazel Blythe & Simon P. Liversedge
University of Southampton, United Kingdom

Although previous research has shown that letter position information for the first letter of a parafoveal word is coded less flexibly than internal or final letters (Johnson, Perea & Rayner, 2007; White et al., 2008), it is not clear how positional encoding operates over the initial trigram. This experiment explored adult readers' pre-processing of letter identity and position information of a parafoveal word's initial trigram using the boundary paradigm during sentence reading. Seven parafoveal previews were generated for 6-7 letter target words: Identity (captain); transposed letter (TL) and substituted letter (SL) nonwords in position 12 (acptain vs. imptain); in position 13 (pactain vs. gartain); and in position 23 (cpatain vs. cgotain). First and single fixation durations, and gaze durations showed a robust transposed letter effect for letters in positions 12 and 23 (but not for 13). Furthermore, reading times between the identity and either TL 12, or TL 23 conditions did not differ, showing that TL previews pre-activate their base word. We conclude that positional letter information for the word's initial trigram is coded in a flexible way through contextual information (bigrams) supporting contextual positional coding models such as Open Bigram (Grainger et al., 2006) or SERIOL (Whitney, 2001).

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Contextual constraint of phonological representations during reading

Patrick Plummer & Keith Rayner
University of California, San Diego & United States of America

Subjects read sentences with target words presented in highly predictable or neutral linguistic contexts. The invisible boundary paradigm (Rayner, 1975) was used to manipulate the available information for target words during parafoveal preview. The preview was either identical to the target word (mail), a heterographic homophone (male), or a control word which was orthographically matched to the target word's homophone (mate). For exactly half of the items parafoveal previews shared, at least, the two initial letters with the target and were classified as orthographically similar. Reading times across all measures showed significant effects of target word predictability. The preview manipulation also yielded significant effects on all first-pass measures. Planned comparisons showed that first-pass reading times were significantly shorter in full preview conditions when compared to orthographic control conditions but not when compared to homophone preview conditions. Critically, there was a significant interaction in orthographically similar items whereby identical and homophone previews in highly predictable contexts resulted in shorter first-pass reading times than all other conditions. These data suggest that readers routinely exploit phonological information during parafoveal preview and that contextual constraint facilitates the extraction of phonological codes consistent with predictable words.

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Synonyms Provide Semantic Preview Benefit in English: Data and a Theoretical Framework

Elizabeth Roye Schotter
University of California, San Diego, United States of America

While orthographic and phonological preview benefits in reading are uncontroversial, researchers have debated the existence of semantic preview benefit with positive evidence in Chinese and German, but no support in English. Two experiments, using the gaze-contingent boundary paradigm, show that semantic preview benefit can be observed in English when the preview and target are synonyms (share the same or highly similar meaning, e.g., curlers-rollers) but not when they are semantic associates (e.g., curlers-styling). These different preview conditions represent different degrees to which the meaning of the sentence changes when the preview is replaced by the target. This continuous variable (determined by a norming procedure) was positively related to reading time (a 1-4 ms increase in reading time for every step up in meaning change, depending on the reading time measure). Thus, similarity in meaning between what is accessed parafoveally and what is processed foveally may be an important influence on the presence of semantic preview benefit. These finding will be discussed in relation to (1) previous failures to find semantic preview benefit in English and (2) the fact that semantic preview benefit is observed in other languages even for non-synonymous words.

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Parafoveal Plausibility Effects on Wordn+1 and Wordn+2 During Reading

Laura J. Wakeford & Wayne S. Murray
University of Dundee, United Kingdom

Failure to find evidence for an associative semantic preview benefit during the reading of alphabetic text has been taken to support the view that lexical processing proceeds in a serial-sequential fashion. This study however, approached parafoveal meaning effects in a novel way, manipulating the plausibility of a preview. Participants read sentences containing critical verb-noun pairs. The preview of the noun was either identical, plausible, anomalous, or an illegal-nonword with the display change triggered as the eye left the verb. There were significant parafoveal-on-foveal plausibility effects on the verb, and significant effects of prior plausibility during inspection of the noun and spillover region. To test the possibility that these effects might stem from mislocated fixations, a four-letter adjective was inserted before the noun; with the display change triggered after the eye left the verb. Preview of the adjective was either identical or an illegal nonword. When identical, the plausibility of the noun preview exerted the same pattern of effects as found in the first study, with a significant 22ms anomalous preview effect. These findings suggest that mislocated fixations cannot account for the reported effects of parafoveal plausibility, suggesting that multiple words can be lexically processed in an overlapping fashion.

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Talks

Special symposium on Binocular Coordination: Applications of reading, spectacle adaptation, dysfunctions and 3D displays - Part I

Thursday, August 15, 14:30 - 15:50

Room: Sångsalen

Chair: Tara Lynn Alvarez

Word identification benefits from binocular input

Stephanie Jainta[1], Hazel, I. Blythe[2] & Simon P. Liversedge[2]
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During normal reading, in most humans vergence eye movements establish sufficient overlap between the two eyes' inputs for a single image of the text to be perceived, and are thought to be a pre-requisite for subsequent visual and cognitive processing. This binocular fusion process typically leads to superior performance, the so-called binocular advantage. We examined the binocular advantage in reading; specifically, we compared binocular and monocular reading in 16 participants whose binocular eye movements were recorded with Fourward Technologies Dual Purkinje image eye trackers. We also included a gaze-contingent manipulation in which viewing changed from monocular to binocular (and vice versa) part-way through each sentence. We observed a stronger word frequency effect in binocular than in monocular viewing conditions, but this manipulation did not modulate vergence eye movements. Importantly, we also found that the viewing condition in the parafovea (monocular or binocular) impacted on the time course of the word frequency effect, as well as affecting processing of the word once directly fixated.

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Implications of isolated visual word recognition for reading text

Richard Charles Shillcock & Mateo Obregón
University of Edinburgh, United Kingdom

More research has been carried out on the recognition of words when they are presented in isolation than when they occur in text, and our theoretical models of the former are more advanced than the latter. The most comprehensive extant model of English isolated word recognition (Obregón, 2013; Obregón & Shillcock, 2012, in prep.) characterizes the role of left-eye/right-eye, structure of the fovea, contralateral and ipsilateral visual pathways, hemispheric coding preferences, complex lexical neighbourhoods, syllabic and morphological structure, handedness, and sex of the reader. We defend this extended domain as the proper domain for reading research on the basis of an explicit, philosophically grounded ontology for this research area (Shillcock, 2013). We project the above model into the task of reading typical connected text and discuss supporting data, existing and new, and a number of implications and predictions.

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Binocular eye movements and accommodation in stereoscopic displays: implications for perception in 3-D media

Simon Watt & Louise Ryan
Bangor University, United Kingdom

3-D stereoscopic displays have become important not only in vision research, but in a wide range of applications including operation of remote devices, medical imaging, scientific visualisation, surgical training, design, and virtual prototyping. An effective stereo display must be comfortable and natural to use, and must create a faithful impression of the 3-D structure of the object or scene being portrayed. Current stereo displays typically fail on both counts, causing discomfort and fatigue, difficulty seeing a single, clear binocular image, and distortions in perceived depth. These problems are caused at least in part by an inappropriate stimulus to accommodation. Because images are presented on a single surface—the pixel grid of a computer monitor, etc.—the focal distance to all points in the scene is constant, irrespective of the depth relations portrayed, resulting in a conflict between the stimuli to vergence eye movements and accommodation. We are exploring the consequences of this conflict for eye movements, accommodation, and perception, as well as evaluating possible solutions.

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Memory-guided binocular gaze shifts: where is what?

Johannes van der Steen, Joyce Dits, Angelique Remmers & Johan Pel
Erasmus MC, The Netherlands

Visual orientation towards remembered or visible visual targets requires binocular gaze shifts that are accurate in direction (version) and ocular distance (vergence). We determined the accuracy of combined version and vergence movements and the contribution of abducting and adducting eye during gaze shifts towards memorized and visual targets in three-dimensional space.

In the test condition subjects were instructed to make a saccade to a remembered) target LED location. In a visually guided control experiment, the target LED remained illuminated during the task. In both conditions gaze shifts consisted of version and vergence movements.

Visually guided gaze shifts had both a fast intra-saccadic and slow post-saccadic vergence component and were most accurate. During memory-guided gaze shifts, the abducting eye was more accurate than the adducting eye. Distance correction was achieved by slow post-saccadic vergence of the adducting eye. Memory-guided gaze shifts that required convergence lacked an intra-saccadic vergence component and were less accurate compared to memory-guided gaze shifts that required divergence.

Visually guided binocular gaze shifts are faster and more accurate than memory-guided binocular gaze shifts. During memory-guided gaze shifts the abducting eye has a leading role and an intra-saccadic vergence enhancement during convergence is reduced.

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Talks

Expertise

Thursday, August 15, 16:10 - 17:30

Room: Stora salen

Chair: Damien Litchfield

Rapid processing of chest radiographs by experts: Insights gained with the 'flash-preview moving window' paradigm

Tim Donovan[1] & Damien Litchfield[2]
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Rapid scene recognition is a global visual process we all have. In medical image perception this ability is used to great effect by radiologists when detecting pathology. Experts rapidly process the low-level information relating to the present image and contrast this information with their extensive experience of previously viewed medical images and quickly detect pathology before actually searching the image. We used the flash-preview moving window paradigm to examine the effects of initial image processing and expertise on eye movement behaviour and task performance. Chest radiographs (preview condition) or a mask were briefly presented and participants (14 experts and 16 novice observers) subsequently searched for a lung nodule which may or may not have been be present using a gaze-contingent window with a restricted field-of-view. Experts performed better than novices, but suprisingly there was no advantage in performance in the preview condition, and novices actually perfomed better in the mask condition ($p = 0.006$). Moreover, there were no significant differences between conditions in eye tracking metrics such as time to first hit. Our results suggest that in this task the preview did not establish a representation for experts which increased performance, and instead decreased performance in novices.

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Is that Safe? Scene Perception and Safety Rating

Diane Ellen MacKenzie & David Westwood
Dalhousie University, Canada

Occupational therapists routinely use observation for evaluation, intervention planning and prediction of a client's functional ability and/or safety within the environment. Determining client safety is a critical practice process that affects client well-being and decision-making for discharge recommendations. This study aimed to establish if differences exist in safety ratings and eye movements between occupational therapists and non-healthcare trained matched individuals. Ten licensed occupational therapists, and ten age/ gender/education-level matched participants completed this eye-tracking study. Participants were asked to use a 5-point scale to rate the safety of static images of simulated clients post-stroke and individuals without stroke completing everyday activities. Images were randomly assigned to one of three exposure times. Eye movements were recorded and compared to determine differences in observational behavior. For all exposure durations, occupational therapists had more polarized safety ratings for stroke-related image content, but little evidence of differences in image eye movements between groups. Additionally, eye movement differences did not emerge in the regions of interest identified by an independent expert panel. These results point to a complex relationship between decision-making and observational behavior in occupational assessment, and highlight the need to explore more than simply "what" features of the image are looked at overtly.

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Searching a house for valuables to steal: The influence of experience with burglary and other offences

Anne P. Hillstrom, Claire Nee, Amy Harding, Kimberly Callan & Joanne Slater International Centre For Research in Forensic Psychology, University of Portsmouth, United Kingdom

Burglary is a visual search task with targets defined largely by non-visual properties (value and ease of transport). Previous research has demonstrated that burglars and other offenders search through houses for valuables more efficiently than non-offenders, focusing their attention on some rooms and not others. We report three studies that investigated whether gaze measures would identify other differences in search behaviour. In all three studies we randomly sampled people in a university setting and classed participants as high or low offenders based on self-reported experience with various kinds of criminal activity. In Study 1, participants explored a real space set up to look like part of a house; Studies 2 and 3 used computer-based simulations of houses. The most common finding was that high offenders completed the burglary quicker and spent a larger proportion of their time looking at high-value objects than low offenders did. To test whether offenders' efficient search was based on having better knowledge of where objects would be located, one study put objects in expected or unexpected locations. There was no effect. Although the results are limited by the participant sample, this is a promising method for exploring the nature of burglary expertise.

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Rapidly Imparting the Skills of Experts to Novice Participants in Threat Assessment Tasks

Carl M. Mann[1], Hayward J. Godwin[1], Nick Donnelly[1], Charlotte A. Riggs[1], Simon P. Liversedge[1], Valerie Benson[1], Michael Boardman[2] & Sarah Smith[2]
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We investigated whether novice participants could be trained to assess scenes for the presence of threat in a similar manner to experts. In these scenes, Improvised Explosive Devices (IEDs) form the primary source of threat. We began by recording eye movement and behavioural measures of a group of experienced military personnel as they conducted threat assessments of a series of photographs taken during the recent conflict in Afghanistan. We then used the data from the experienced personnel to develop a series of training regimes designed to impart their knowledge to a group of novices. We did this using both Feed-Forward Eye Movement (FFEM) training, where novice participants are presented with footage from expert eye movement behaviour, and error management training, where novice participants are informed with regards to the manner in which experts responded at a behavioural level. Novices were assigned (using a double-blind procedure) to one of four training conditions formed from orthogonal combinations FFEM training (present/absent) and error management training (present/absent). The results indicated that the performance of novices was only modified when given combined FFEM and error management training.

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Capturing learning effects on eye movements in repeated measures experiments

Martin Petri Bagger[1], Jacob L. Orquin[1], Susann Fiedler[2] & Simone Müller Loose[1,3]

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We propose and illustrate that repeated exposure to stimuli sets increases the size of the saccade amplitudes. Saccadic amplitudes are closely related to the perceptual span and therefore used as a measure for the information intake in an experiment. Studies on expertise have shown that experts, compared to novices, have larger saccades and the results on decision times and amount of information search in simple choice experiments indicated that these effects occur also within a single experiment. These findings are particularly important in experiments which use assumptions about the perceptual span in order to define areas of interests and focus their analysis on the information that is ignored in the information search process. If the perceptual span increases over the course of an experiment the researchers are at risk of falsely classifying stimuli as not being attended. We conducted a discrete choice experiment with 68 participants. The results consistently demonstrate an increase of the saccade amplitude over the course of the experiment independently of condition. We conclude by discussing our results in the light of the possible increase of the perceptual span and its implications for the research procedure in eye-tracking experiments with a repeated measurement design.

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Talks

Methods II

Thursday, August 15, 16:10 - 17:30

Room: Nya fest

Chair: Kenneth Holmqvist

The Geometry, Topology, and Morphology of Looking

Oliver Hein, Lea Mainz, Thomas Wriedt & Wolfgang Zangemeister
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Recent years have seen a remarkable growth in the way mathematics and computer sciences can process data. In disciplines like Pattern Recognition, Clustering, Computer Vision, Information Retrieval, Molecular Biology, etc. many new methods have been developed to cope with the ever increasing complexity of the data. These new methods offer interesting possibilities to scrutinize and more important to interpret and classify eye-tracking data. The talk addresses some first applications how these methods can significantly improve the evaluation of eye-tracking data. The task for the ternary classification of eye-tracking data into saccades, fixations, and smooth pursuits is discussed, and the hierarchical ordering of the eye tracking data in fixations, and regions of interest is shown. Furthermore the classification of a public available eye tracking data set into groups of different viewing behavior is demonstrated. The goal is to build up the modeling of gaze-trajectories, and looking strategies in dynamic environments ab initio on mathematical grounds. All the discussed algorithms and results for data are implemented in the software dyRoI (dynamic Region of Interest), which is intended to evaluate and compare large data sets of many subjects for still and dynamic test paradigms in eye-tracking studies in neurology, psychology, marketing, etc.

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Do pupil-based eye trackers measure eye movements? Relative movements between the pupil- and iris centers directly after saccades

Marcus Nyström[1], Ignace Hooge[2] & Kenneth Holmqvist[1]
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Video-based eye trackers that estimate the gaze direction by observing the pupil produce post-saccadic oscillations (PSOs) in the recorded eye movement data. While their cause is largely unknown, PSOs make it difficult to accurately detect saccade offsets and fixation onsets. By extracting pupil and iris borders from eye images recorded with the SMI Hi-speed 240 Hz system during and directly after a saccade, we compared the movements of the pupil- and iris centers in three participants performing repetitive horizontal saccades. Results showed a discrepancy between how the pupil and the iris moved during the post-saccadic period; the pupil oscillated with a higher frequency and a larger amplitude than the iris. This suggests that the pupil moves relative to the iris. Moreover, we found that the extracted pupil movement was highly correlated with the recorded eye movement data. Taken together, this means that the eye tracker measures pupil movement rather than eyeball rotation.These results emphasize that when interested in the the fine details of eye dynamics, it is important to consider which ocular structure that is measured.

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Detection of fixations and smooth pursuit eye movements using local and global properties of the eye-tracking signal

Linnéa Larsson, Martin Stridh & Marcus Nyström
Lund University, Sweden

When the eye is following a moving target the eye movement is referred to as a smooth pursuit. Smooth pursuit detection is increasingly important in eye-tracking studies since they more often include video as stimuli compared to earlier when mainly static images were used. When the signals also contain smooth pursuit eye movements, traditional algorithms used for detection of fixations and saccades are not useful since the properties of smooth pursuit movements overlap with other types of eye movements. We therefore propose a new algorithm that is able to separate between fixations and smooth pursuit movements in signals recorded during video stimuli. The method comprises three stages: First, the local behavior of the signal is computed by determining the direction and dispersion of the signal in a short sliding window. In the second step, the properties of the local behavior are compared between consecutive windows, and, finally, a global overview of the signal is obtained by evaluating the sequence of neighboring events. The performance of the proposed method is evaluated using a specialized annotated database recorded during video stimuli. Preliminary results indicate a good agreement between detection results and annotations.

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Lens mobility influences post-saccadic ringing in video-based eye tracking

Samuel Barnaby Hutton
University of Sussex, United Kingdom

Post-saccadic ringing has been observed in eye movement recordings from both dual Purkinje image (DPI) and video-based eye trackers, where it can create ambiguity in determining saccade duration, amplitude and peak velocity. Research suggests that the ringing observed in DPI recordings reflects lens wobble picked up from the fourth purkinje image, but it is unclear whether lens wobble is also the source of ringing observed in video-based eye trackers (which determine gaze based on the relative location of the centre of the pupil and the corneal reflection). Accommodation increases lens mobility by releasing tension on the zonular fibres that support the lens. We manipulated accommodative effort whilst participants saccaded to horizontal and vertical targets and recorded eye movements using a video-based eye tracker. Post-saccadic ringing was significantly increased at high levels of accommodative effort, suggesting lens wobble is a source of post-saccadic ringing in both DPI and video-based recordings. The consequences of this ringing for perception and decisions about classifying this portion of eye movements remain to be determined.

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Properties of post-saccadic oscillations induced by eye trackers

Ignace Hooge[1], Marcus Nyström[2], Tim Cornelissen[1] & Kenneth Holmqvist[2]

[1]Experimental Psychology, Helmholtz Institute, Utrecht University, the Netherlands
[2]The Humanities Laboratory, Lund University, Sweden

Recent research shows that video based eye trackers produce post-saccadic oscillations (PSO). These PSOs are caused by pupil movement relative to the iris and may severely hamper determination of saccade endings (Nyström & Holmqvist, 2010). To be able to develop a method to remove this ringing artifact from the data we investigated the nature and probable cause of eye-tracker induced PSO by conducting 2 experiments.

In the first experiment, four subjects made binocular saccades of varying amplitude in different directions. Due to simultaneous occurrence of both fast PSO (± 30 Hz) and slow idiosyncratic post saccadic drift, isolation of PSO is quite difficult. Also, the nature of the combined post-saccadic movements differs between individuals for different saccades.

In the second experiment, we investigated whether the aforementioned pupil oscillations are related to pupil size. Four subjects made horizontal saccades and pupil size was manipulated by varying the background lighting. To investigate pupil oscillations, we analysed eye images produced by the eye tracker. Amplitude of the pupil oscillation was slightly larger with smaller pupil size.

Conclusions: Post saccadic oscillations in data obtained with a video eye tracker differ a lot between individuals; pupil size seems to affect PSO, but only slightly.

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Talks

Language-related processes in reading II

Thursday, August 15, 16:10 - 17:30

Room: Lilla salen

Chair: Simon P. Liversedge

The effect of high- and low-frequency previews and sentential fit on word skipping

Bernhard Angele[1], Abby Laishley[2], Keith Rayner[1] & Simon P. Liversedge[3]
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In a previous gaze-contingent boundary experiment, Angele and Rayner (2012) found that readers are likely to skip a word that appears to be the definite article "the" even when syntactic constraints do not allow for articles to occur in that position. In the present study, we investigated whether the frequency of the preview of a three-letter target word influences a reader's decision to fixate or skip that word. We found that the preview frequency rather than the felicitousness (syntactic fit) of the preview affected how often the upcoming word was skipped. These results indicate that visual information about the upcoming word trumps information from the sentence context when it comes to making a skipping decision. Skipping parafoveal instances of "the" therefore may simply be an extreme case of skipping high-frequency words.

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The Effect of Word Frequency and Complexity on Eye Movements during Chinese Reading

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Frequency and complexity (number of strokes) of a word are key factors determining whether, and for how long, readers fixate that word in normal reading. However, the joint influence of the two variables is not clear. We monitored eye movements of native Chinese readers when they read sentences containing single-character target words orthogonally manipulated for frequency and complexity. Both factors yielded strong main effects on skipping probability but no interaction, with readers skipping visually simple and high frequency words more often. However, frequency and complexity did not show main effects on fixation times on the target words and only a marginal interaction with slightly longer fixations for the low frequency, visually complex words. In all likelihood, fixation times were influenced by high skipping rates creating a paucity of data for the analyses and also compromising fixation times when readers erroneously landed on the target words. The weak interaction does suggest a frequency effect in fixation times for the conditions with the lowest skipping rates (i.e. high complexity). The results demonstrate that word complexity and frequency have independent influences on saccadic targeting behavior during Chinese reading. Results will be interpreted in relation to the nature of lexical processing in reading.

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Morphological structure influences saccade-target selection during reading of Uighur sentences

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Low-level features such as inter-word spaces are generally considered to be responsible for saccade-target selection during reading and there is no consistent evidence that high-level information influences initial fixation landing-positions. In the present study, two experiments were carried out from both corpus-analytic and experimental control approaches, aiming at testing the effect of morphological structure on saccade-target selection during reading of Uighur script, which is a an Arabic-derived alphabet writing system used by a Turkic ethnic group of people primarily living in People's Republic of China. In both experiments, we demonstrate that in addition to word length and launch site, the number of suffixes can also influence fixation landing positions during reading of Uighur sentences: first-fixations were directed further towards the word beginnings for morphologically more complex words. These results are difficult to explain purely by low-level guidance of eye movements and indicate that due to properties specific to Uighur script such as its rich suffixes, low-level visual information and high-level information such as morphological structure of parafoveal words may jointly influence saccade programming. These results together also provide a convincing demonstration that statistical and experimental control techniques lead to the same conclusions.

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Lexical expertise and parafoveal processing

Aaron Veldre & Sally Andrews
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We investigated the extent to which individual differences amongst skilled adult readers modulate parafoveal processing. Participants, who were assessed on measures of reading comprehension and spelling ability, read sentences in which the length and orthographic preview of an upcoming word was manipulated using the boundary paradigm. The difficulty of the pre-target sentence was also manipulated to determine whether the effects differed as a function of foveal load. The results showed that the amount of parafoveal preview benefit depended on 'lexical expertise', defined by the combination of effective reading comprehension and accurate spelling. Increased reading ability was associated with a larger preview benefit, particularly in difficult sentences, but only amongst good spellers. The benefit of lexical expertise was greatest when the preview length was accurate, but these effects were restricted to first fixation and single fixation duration, suggesting that lexical expertise affects saccade targeting in addition to lexical processing. Analyses of landing position confirmed that lexical experts were most likely to adjust their saccades on the basis of parafoveal orthographic information. The results indicate that lexical quality plays an important role in eye movement control and affects parafoveal lexical processing as well as saccade targeting.

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Talks

Special symposium on Binocular Coordination: Applications of reading, spectacle adaptation, dysfunctions and 3D displays - Part II

Thursday, August 15, 16:10 - 17:30

Room: Sångsalen

Chair: Tara Lynn Alvarez

Cerebellar and pontine involvement in binocular coordination: insights from lesion studies

Andreas Sprenger[1], Thurid Sander[1], Holger Rambold[1,2] & Christoph Helmchen[1]
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Visual foveation of objects in 3D space essentially needs proper control of the two eyes fixating objects both in direction (horizontal, vertical or both) and in depth (far vs. near). Optimal functioning of these movements separately and of their combination is a prerequisite for single binocular vision (cortical fusion of the two retinal images) allowing perception of depth and stereovision. The cerebellum is part of the cortico–ponto–cerebellar circuit for conjugate eye movements. Recent animal data suggest an additional role of the cerebellum for the control of binocular alignment and disconjugate, i.e. vergence eye movements. The latter is separated into two different components: fast vergence (to step targets) and slow vergence (to ramp and sinusoidal targets). In our studies patients with rostral pontine lesions with NRTP involvement revealed impaired fast vergence, whereas patients with caudal pontine lesions showed normal fast vergence eye movements. In patients with cerebellar lesions we found impaired slow vergence whereas fast vergence was nearly spared. All defects were particularly expressed in patients with lesion involvement of vermal structures. We conclude that the human cerebellum, in particular the vermis, and the pons are involved in the processing of dynamic vergence eye movements.

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Binocular asymmetry– Comparison of controls to patients with convergence insufficiency before and after vergence training

Tara Lynn Alvarez & Eun H. Kim
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The binocular coordination of eye movements in patients with convergence insufficiency (CI) is incompletely understood. The left and right-eye movement peak velocity was quantifed from 17 subjects (10 binocularly normal controls (BNC) and 7 CIs). Four of the CI subjects participated in 18 hours of vergence training. The vergence peak velocity symmetry ratio was computed as the eye movement response with the slower peak velocity divided by the peak velocity from the faster eye movement response. Controls had a mean with one standard deviation ratio of 0.93±0.06°/s, significantly more symmetrical than the CI patients whose ratio was 0.77±0.09°/s ($t=5.3$; $p<0.0001$). For the CI subjects who participated in vergence training, a paired t-test revealed significantly more symmetrical left and right-eye movement responses with a ratio of 0.93±0.11°/s ($t=5.6$; $p=0.03$) after training compared to baseline responses. Results support that one potential mechanism that vergence training is facilitating is an improvement in the symmetry between left and right eye responses.

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Correcting binocular imbalance with prisms: specific effects on objective and subjective measures of fixation disparity

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Spectacles including prisms can be prescribed to compensate for oculomotor imbalance: an exo or eso fixation disparity is intended to be corrected by prisms with base-in or base-out direction, respectively. We applied the MKH-procedure (Measuring and Correcting Methodology after H.-J. Haase) and prescribed prisms up to 8 prism dioptres.

Vergence measures were assessed in 24 participants, initially without prisms and again with the prisms after constant wear of 36 days, on average. We measured two aspects of fixation disparity: objective fixation disparity was recorded with a modified application of the EyeLink II video eye tracker and subjective fixation disparity was tested with dichoptic nonius lines.

We found specific effects due to prism direction: subjective fixation disparity shifted in the eso direction only by base-in prisms, while objective fixation disparity shifted in the exo direction only by base-out prisms. This pattern of result emphasizes the different inherent physiological mechanisms of objective and subjective fixation disparity, which may reflect the oculomotor misalignment of the visual axis and a sensory deviation after neural mechanisms of stabilization and compensation, respectively. We conclude that - despite vergence adaptation - effects on fixation disparity seem to be present after wearing prisms.

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Evidence of Fast Component Preprogramming In Vergence Eye Movements

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Considerable evidence supports the theory that vergence eye movements are driven by two motor components: a fast component that dominates the initial response and a slow component during the latter portion of the movement. Based on neurophysiological evidence, it is generally assumed that the fast component is open-loop although there has been no experimental evidence to support this assumption. Conversely, the late response is assumed to be feedback controlled given the highly accurate final positions attained by the vergence response system. Here, the dynamics of vergence responses to 4degree steps are analyzed. These responses are first segmented into early and late sections based on time response characteristics. We demonstrate that vergence responses to fixed stimuli (such as 4degree steps) do not closely follow the main sequence: (the ratio of response maximum velocity to amplitude). This behavior is evident given that step responses to the same stimulus (ie, 4 degree steps) have constant final amplitudes but show a range of peak velocities; thus indicating a range of main sequence values. However, the fast component segments closely adhere to the main sequence, exhibiting saccade-like behavior, and providing strong evidence that the fast component is indeed open-loop. These results extend previous "dual-mode" theories.

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Talks

Special symposium on eye movements during scene perception: current experimental findings and modeling results

Friday, August 16, 10:20 - 12:20

Room: Stora salen

Chair: Jochen Laubrock

Real-world tasks with full control over the visual scene: combining mobile gaze tracking and 4pi light-field measurements

Josef Stoll[1], Mandana Sarey Khanie[2], Sandra Mende[3], Jan Wienold[3], Marilyne Andersen[2] & Wolfgang Einhauser[1,4]
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[4]Center for Interdisciplinary Research (ZiF), Bielefeld, Germany

Measuring gaze allocation during scene perception typically faces a dilemma: full control over the stimulus requires comparably constrained scenarios, while realistic tasks leave the visual input hard to control. We propose to capture the full (4pi) light-field of an office space, while participants perform typical office tasks. Using a wearable eye-tracking device ("EyeSeeCam"), gaze, head and body orientation are measured along with subjective well-being and performance. In the present study, 52 participants performed four office tasks ("input", "reflection", "output", "interaction"), each with three different tools (phone, computer, paper) under varying lighting conditions and outside views. We found that eye and head were fundamentally differently affected by view and that this dependence was modulated by task and tool, unless participants' task was related to reading. Importantly, for some tasks head movements rather than eye movements dominated gaze allocation. Since head and body movements frequently remain unaddressed in eye-tracking studies, our data highlight the importance of unconstrained settings. Beyond assessing the interaction between top-down (task-related) and bottom-up (stimulus-related) factors for deploying gaze and attention under real-world conditions, such data are inevitable for realistic models of optimal workplace lighting and thus for the well-being of an workplace's occupant.

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A dynamical model of attentional selection for saccades during scene viewing

Hans A. Trukenbrod[1], Felix A. Wichmann[2] & Ralf Engbert[1]
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When viewing a scene, we reorient our fovea about three times per second to inspect areas of interest with high visual acuity. Stimulus-driven (bottom-up/saliency) factors as well as task (top-down) factors have been identified to predict individual fixation locations. However, little is known about the dynamical rules that induce the generation of sequences of fixations (i.e., the eye's scanpath). Here we propose a computational model to investigate the dynamical interaction between the build-up of saliency and the the inhibition of recently selected targets. In our model, fixation sequences are determined by the interaction of two processing maps. In a first map, an attentional processing window generates the build-up of a saliency field by dynamical rules. A secondary motor map keeps track of recently fixated targets. Finally, both map interact to generate a movement-planning field for saccadic eye movements. Our simulations predict properties of the experimentally observed eye-movement data, e.g., distribution of saccade amplitudes. The new computational model represents a promising framework to investigate the link between internal saliency of a scene and subsequent target selection during free viewing of natural scenes.

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Control of saccade timing by foveal and peripheral spatial frequencies in natural scenes

Anke Cajar, Jochen Laubrock & Ralf Engbert
University of Potsdam, Germany

Visual processing is spatially inhomogeneous with the foveal visual field being specialized in processing fine detail (high spatial frequencies) for object recognition and the peripheral visual field being specialized in processing transients and coarse information (low spatial frequencies) for saccade target selection. This functional segregation has often been ignored when studying what guides the eyes through a complex natural scene. Here we investigated the effects of gaze-contingent spatial frequency filtering on eye movements. In several experiments, low or high spatial frequencies were attenuated in the foveal or peripheral visual field, thus simulating foveal scotoma or tunnel vision. Compared to a control condition, foveal filtering yielded longer and peripheral filtering shorter saccade amplitudes, indicating that subjects preferentially programmed saccades to unfiltered scene regions. Fixation durations were longer when spatial frequency filters maintained more useful information (foveal high-pass, peripheral low-pass). Thus, saccade programs were inhibited more strongly when visual processing was less impaired. We developed a computational model based on parallel random walks for saccade timing, foveal and parafoveal processing. We will discuss our experimentally observed effects of fixation durations in the context of the mathematical model.

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Saccadic decisions in scene viewing

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Much has been learnt about the neural mechanisms of decision by studying reaction times, notably of saccadic eye movements in response to suddenly-presented visual targets. However, in real life, most saccades are not evoked in this way, but made spontaneously while viewing complex visual scenes. Here we describe saccadic decisions using likelihood theory, where decisions to move the eyes are made when the evidence in favour of moving to a new location in the scene outweighs the evidence for not moving to that location sufficiently. This decision process is implemented using the LATER (Linear Approach to Threshold with Ergodic Rate) model. In the present work we consider how the dynamics of the decision processes underlying saccade timing in natural scenes are influenced by different aspects of the visual scene. We show that saccade timings are sensitive to information both at the current fixation location and at the target of the next saccade. While both low- and high-level visual information influence decision times, higher-level semantic information dominates. From these findings we propose a decision-map framework for explaining fixation selection in space and time when viewing complex images.

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Relating fixation patterns to scene descriptions: Implications for computational approaches to scene understanding

Gregory Zelinsky, Hossein Adeli, Kiwon Yun, Dimitris Samaras & Tamara Berg
Stony Brook University, United States of America

The eye movements that people make while viewing scenes contain an abundance of information about how scenes are comprehended and understood. In a series of experiments we measured oculomotor behavior as participants viewed scenes in preparation for the task of producing a verbal description of each following its offset. We then related this viewing behavior to the descriptions, with each description serving as a ground truth for how that scene was understood. Several analyses are reported, including the probability of describing an object given that it was fixated, the probability of fixating an object given that it was described, and the object categories for which these relationships were most pronounced. Other analyses looked at where on these objects people chose to fixate, and whether this information was valuable for object detection. We also combine gaze behavior with a deformable part model of object detection in an attempt to automatically segment those objects contributing most to scene understanding, and report efforts to decode patterns of fixations to classify whether a scene depicts interacting people or not. Collectively, these findings suggest that embedded in viewing behavior is information about the content of a scene and how it is understood by a viewer.

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Talks

Human factors

Friday, August 16, 10:20 - 12:20

Room: Nya fest

Chair: Kenneth C. Scott-Brown

Evaluation of 2D and 3D terrain visualization

Stanislav Popelka & Alžběta Brychtová
Palacký University in Olomouc, Czech Republic

The eye-tracking study was focused to analyze differences between user cognition of 2D and 3D terrain visualization.

Computer generated 3D terrain visualizations are widely used and should be more understandable for people without cartographic education. For cartographers, contour lines visualization should be more efficient.

Within the study, two eye-tracking experiments were designed. First of them contained 2D and 3D terrain visualization in one stimuli. It was found that position of each visualization (left or right) has higher impact for the user's gaze preference than visualization itself. Because of that, another experiment containing only one type of visualization in the stimulus was created.

Two scanpath comparison analyses were run. First was based on the order of visited AOI's and the second one on the scanpath shape.

Results of this study indicate, that both groups of users (cartographers and non-cartographers) used a different strategy during solving the geographical task.

SMI RED 250 eye-tracker was used during the study. For data analyses, OGAMA, CommonGIS and eyePatterns software was used.

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Trend vs. Safety - do road sweepers and snowplows really need a touchscreen?

Manuela Lackus & Michael Gugg
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During last years an increasing use of driver assistance systems and touchscreens in passenger cars can be stated. These systems are progressively used in commercial vehicles or – as a new trend – in municipal vehicles. This study deals with the usability of touchscreens for road sweepers and snowplows, after an Austrian manufacturer of municipal vehicles planned to implement the technology. Together with the university of applied sciences in the field of design and product management the placing and the usability of the touchscreen on the a-pillar or on the centre console was tested. Safety was set as dependent variable; the indicators were distraction from environment, duration of distraction from driving, duration of manipulation of screen, the ease of returning to primary driving task, physical location of the distraction and the driver's ability to divide attention and perform multiple tasks.

Parallel to a HED-Tracking a System Usability Scale and qualitative interviews as well as observations were carried out with 7 drivers of municipal vehicles.

After the study has showed a high risk in safety aspects the implementation was stopped for the moment and economic disadvantage could be anticipated. The present example shows the important transfer of applied research to companies.

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Using eye tracking to describe monitoring behaviour during a passive and an active control task

Catrin Hasse, Hinnerk Eißfeldt, Peter Maschke & Carmen Bruder
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Increasing automation requires operators to monitor adequately. Adequate monitoring involves specific phases: orientation, anticipation, detection and recheck. Previous studies have described eye tracking parameters underlying the monitoring process. The present study examines the effect of a monitoring task on eye movements within the monitoring process. A passive control task (reporting automation failures) was compared to an active control task (assuming control if automation fails). Participants performed both tasks while their eye movements were recorded. Eye tracking data were categorized into monitoring phases and related to relevant AOIs (areas of interest). The data imply that eye movements adapt to the demands of the monitoring task and phase. Fixation counts and gaze durations on relevant AOIs were higher for active than passive control, and were particularly high during the orientation phase compared to other monitoring phases. Identifying relevant AOIs at the beginning of a monitoring process is thus crucial, especially in the active control condition.

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Expert eye guidance in multiplex CCTV operation

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We report the results of a mobile eye-tracking study of CCTV operator performance during day and night shift team based use of a city-centre control room under normal team-working conditions. During daytime operations fixations were observed on the 68% of the multiplex monitors on the control room wall during a 15 minute period. Fixations during night-time operation were restricted to 25% of the screens, reflecting the differing nature of day and night-time activity in the city. Total multiplex fixations constituted less than 10% of the recorded fixations. However, the operators were observed to make rapid use of all of the visual information sources in the control room, including visual information on their partners monitor and on the multiplex. In addition, we observed systematic use of cameras displaying different views of the city to ensure continuity of coverage, suggesting that gaze locations were governed by knowledge of the likely location of emerging activity and targets rather than on the low-level conspicuity of the visual array. This suggests that task requirements and underlying knowledge of multiple scene layout are crucial in the prediction of gaze allocation in CCTV operation.

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Method of gaze data analysis for marine ship's simulator researches. Evaluation of officer's of the watch eye metrics

Bartosz Muczyński & Maciej Gucma
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A ship's navigation bridge is a highly specialised and complex working environment. Most commonly, it is managed singlehandedly by an officer for the majority of time. The officer is responsible for the monitoring of the totality of the navigational equipment and for making decisions based upon the received data during his entire navigational watch of four hours. There are two main problems closely related to this question. The first one is the lack of standards and methods of testing of the bridge's construction, or of the ergonomics of the navigational equipment. The second one is the concern related directly to the training of the future officers. The use of the eye-tracker on the navigation bridge makes it possible to objectively measure the ergonomics of the individual interfaces as well as to evaluate the decision-making process itself, including the mental workload and stress. This article presents an experiment conducted in a marine ship's navigation bridge simulator. In the experiment, officers were faced with an unexpected and sudden situation leading to a collision. The simulated situation required the officer to act immediately and resolutely, taking into account all his knowledge about the ship, and interpreting the available data correctly.

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Analysis of Eye Movements in Situated Natural Interactions

Thies Pfeiffer[1] & Kai Essig[2]
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Studying and analyzing eye movements in natural interaction situations in the field – as opposed to restrictive laboratory settings – is a dream coming true with recent developments in hard- and software. Areas of interest include situated communication, sports, economics or human factors. These new opportunities, however, also challenge current methodological approaches in basic research. Traditional eye-tracking parameters as indices for visual attention processes and established methods for scientific visualization, such as heatmaps or scanpaths, have to be carefully reconsidered when everything is dynamically in motion – as it is often the case in natural interaction situations. Many measures do not consider variations in applications fields, stimuli types, environments and multi-modal recordings, such as 3D object occlusions. The analysis of situated eye movements is even more challenging, as the flexibility gained with mobile eye tracking goes along with a significant increase of annotation time and complexity.

Based on our own experiences drawn from various studies using mobile eye tracking, the talk discusses the challenges and reviews state-of-the-art approaches for the analysis of eye movements in natural behavior, including manual and automatic annotations of situated eye movements and combinations of eye tracking and motion capturing both in the field and lab.

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Talks

Special symposium on the decision of fixating vs. moving the eyes: Fixation-system, equilibrium and lateral-interaction accounts discussed

Friday, August 16, 10:20 - 12:20

Room: Lilla salen

Chair: Soazig Casteau

Competing motor programs and fixation maintenance: why are identical peripheral stimuli sometimes effective in triggering microsaccades and sometimes not?

Ziad M. Hafed
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As described by Krauzlis and colleagues, the equilibrium hypothesis suggests that population coding of saccades extends even in the foveal zone of the superior colliculus (SC). An attractive feature of this hypothesis is that it can explain why fixation maintenance might be interrupted by microsaccades, especially after stimulus onsets. Such onsets cause a robust, machine-like alteration of microsaccades, and in my talk, I will describe how disrupting SC activity also disrupts this alteration. I will then test a strong prediction of the equilibrium hypothesis, by asking why the same peripheral onsets can sometimes trigger microsaccades and sometimes not. According to the hypothesis, a microsaccade might be more likely to be triggered if the representation of the currently foveated goal is already biased slightly away from straight ahead: this makes it easier for, say, peripheral SC activity to trigger a movement. I will first show that stabilizing the image of the foveated target on the retina reduces microsaccades, consistent with a reduced variability of the target's position representation. I will then show how the effectiveness of a given peripheral stimulus on microsaccades can be strongly modulated simply by controlling the retinotopic position of the foveated goal at the stimulus onset time.

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The equilibrium hypothesis and population coding in the superior colliculus

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The equilibrium hypothesis is an extension of the classic idea that saccades are controlled by a population code in the superior colliculus (SC). This principle relies on the fact that the SC contains a visual map, and that the activity of each SC neuron amounts to a "vote" depending on its retinotopic position. During the last decade, evidence has been provided demonstrating that this principle also applies to the foveal part of the SC map. Specifically, neurons in the foveal SC neurons are active during fixation, but also during microsaccades, small regular saccades, and smooth pursuit – supporting the idea that foveal SC activity represents the retinotopic location of the target, rather than a command for a specific motor outcome. When foveal SC neurons are inactivated, eye position shows systematic and stable offsets from the actual target position – consistent with the idea that reading out activity from a distorted population code provides a biased estimate of where to aim the eyes. More generally, this theory suggests that visual fixation is an equilibrium condition established by target position signals issued bilaterally from the SC, and that saccades are triggered when this equilibrium is disturbed, in order to restore balanced activity.

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Role of the Superior Colliculus in the Gap Effect

Douglas P. Munoz[1] & Robert A. Marino[2]
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The introduction of a short period of darkness (gap) between the disappearance of a fixation point (FP) and the appearance of a visual saccadic target reduces saccadic reaction time (SRT). This gap manipulation conveys both a top-down temporal warning component and a bottom-up change in luminance of visual input at the fovea. These warning and luminance signals converge in the Superior Colliculus (SC) where they influence saccade planning. We recorded from SC neurons in monkeys trained to perform the gap saccade task and we manipulated FP luminance during the gap period to dissociate warning effects from luminance effects. The size of the gap effect (reduced SRT) scaled with the magnitude of the decrease in FP luminance during the gap period. Neural recordings in the SC showed that luminance modulated changes to the gap effect scaled with pre-target increases in caudal SC saccade-related neurons and decreases in rostral SC fixation-related neurons. These data suggest that the gap effect is strongly influenced by BU luminance changes on the fovea that disengage fixation anchoring mechanisms in the rostral SC.

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Dynamic modulation of the superior colliculus by the cortical encoding of predictable intervals: a neural field model of eye-movement decisions

Dominic Standage[1] & Michael C. Dorris[2]
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The superior colliculus (SC) is engaged in the integration of sensory and cognitive information during eye-movement decisions. The involvement of SC in decisions is revealed by ramping activity during predictable intervals of mixed-strategy games, where selectivity for an upcoming choice increases over time. SC neurons that do not encode task relevant information also show ramping activity during pre-choice intervals, but at lower rates (Thevarajah et al, J Neurosci, 2009). This profile of activity suggests that competitive dynamics in SC are modulated by spatially non-selective timing signals (Standage et al, PLoS Comput Biol, 2013).

We hypothesize that the encoding of temporal intervals in the frontal eye fields (FEF) controls spatially non-selective disinhibition of SC via the caudate nucleus and substantia nigra pars reticulata. To address this hypothesis, we simulated a mixed-strategy game with a neural field model of SC, in which excitatory populations encoding spatial location compete through a common inhibitory pool. The model reproduces neural activity recorded from SC and its corresponding behavioural outcomes, providing mechanistic explanations for the differential spatial selectivity of ramping activity in FEF and SC, the time-evolution of choice-selectivity by SC neurons, and microstimulation-induced saccadic deviations.

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When to move the eyes: Re-examining alternative accounts in light of human behavioral data

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Alternative hypotheses account for "when" the eyes move in complex visual displays. We will first review human-behavioural findings suggesting that the triggering of a saccade does not result from lateral interactions, i.e. short-range excitation and long-range inhibition, within the Superior-Colliculus map, but most likely reflects competition between fixation and move systems. These findings show that (1) saccade latencies are rarely shortened when a distractor is displayed near the target, and (2) the effect of remote and proximal distractors on saccade latency depends on the ratio between distractor and target eccentricities, but not the inter-stimulus distance in visual or collicular space. We will then present a new study, which reinvestigated remote- and proximal-distractor effects, but as a function of the relative location of the stimuli (i.e. the distractor was either more or less eccentric than the target), and their saliency (empty vs. filled). For long inter-stimulus distances, the lateral-interaction hypothesis predicted no main variation of the distractor effect with the relative location of the stimuli. However, the fixation-system hypothesis predicted a reversal of the distractor effect, from inhibition to facilitation when the distractor moved from a less-eccentric to a more-eccentric location than the target, but modulated by stimulus saliency.

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Inhibition of saccade initiation improves saccade accuracy: evidence in support of a fixate system

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The accuracy of target elicited saccades worsen when a distractor is shown close to the target location. However, the presence of a further distractor, remote from the target and closer distractor, increases the saccade response latency and improves its accuracy. It is suggested that this may be due to the second, "remote distractor" impacting directly on the competition which takes place between the target and closer distractor or simply because the remote distractor only impairs the ability to disengage from fixation. To tease these apart, we directly examined the relationship between the latency and accuracy of saccades made to a target and close distractor, as a proxy for the developing competition between them, while varying the distance of the remote distractor. We found that accuracy improvements followed a similar pattern regardless of the presence of the remote distractor providing evidence against a direct impact of the remote distractor on target selection processes. This suggests that the remote distractor does not act directly on the competition between the target and close distractor but rather increases latency through increasing activity at fixation.

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Talks

Special symposium on eye movements to blank spaces during memory retrieval

Friday, August 16, 10:20 - 12:20

Room: Sångsalen

Chairs: Roger Johansson, Agnes Scholz

Eye Movements during Pictorial Recall

Corinna S. Martarelli & Fred W. Mast
University of Bern, Switzerland

Are eye movements to "nothing" epiphenomena (symbol-structure position) or do they have a functional role (pictorial position)? We investigated eye movements during pictorial recall. Participants had to recall previously seen stimuli in order to respond to specific questions. We have carried out two studies.

1) Participants (children and adults) spend more time in the areas where they previously encoded the stimuli. Interestingly, this only occurred with correct trials. The comparison between children and adults showed no differences in looking times (spatial location), whereas performance (object memory) ameliorated with age (Martarelli & Mast, 2011).

2) We found that the location of visual stimuli is stored in long-term memory (one-week delay). Additional eye position manipulation showed no differences in accuracy and in looking times: the encoding of spatial information cannot be disrupted easily (Martarelli & Mast, 2012).

The results are partially in line with the pictorial position but also with the symbol-structure position. It seems that while encoding a pictorial object, the viewer builds up a representation that launches eye movements to the original locations during retrieval. Both the earliness and the stability of the "corresponding area effect" highlight the importance of eye movements that are encoded with the whole memory trace.

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Eye movements to empty spaces have an active role during visuospatial memory retrieval

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Several studies have reported that spontaneous eye movements occur with visuospatial imagery and that they closely reflect content and spatial relations from an original picture or scene during memory retrieval. While it has been claimed that a reactivation of the oculomotor system towards locations on an emptied display can act as an important retrieval cue in this process, there is to date no conclusive evidence for such an effect.

The present study was designed to address this fundamental issue by imposing different eye movements on participants during memory retrieval of visuospatial information.

Eye movements were recorded from 24 participants who recalled properties and spatial arrangements of sets of objects under four different manipulations: (1) free viewing on a blank screen; (2) gazing at a fixation cross; (3) looking at an area which was congruent with the original locations of the objects to be recalled; (4) looking at an area which was incongruent with the original locations of the objects to be recalled.

Results provide evidence that eye movements can indeed modulate memory performance of visuospatial information, both in respect to retrieval accuracy and to response times, and specify the circumstances under which those eye movements can facilitate/perturb memory performance.

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The function of looking at nothing: Eye movement to an absent object benefits the memory for it

Jie Li[1,2], Ying Zhou[2], Xiang Huang[2], Jie He[2] & Mowei Shen[2]
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People frequently "look at nothing", that is, moving eyes to an empty location previously occupied by an object. The present study investigated whether such behavior has a function in the memory for the corresponding object. The results showed that when two arrows were presented and then disappeared, making a saccade to the now-empty location previously occupied by one of them led to higher memory precision for it than the other one. The results held true when the encoding and probing stages were controlled equal for both arrows, indicating that the eye movement to the empty location benefits the maintenance of the corresponding object representation. The present study suggests that "looking at nothing" is a functional behavior. It is just like "looking" at the corresponding representation in the internal memory, so that the representation could be continuously activated and maintained with high precision.

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Covert shifts of attention decrease retrieval performance while fixating blank locations

Agnes Scholz & Josef Krems
Chemnitz University of Technology, Germany

When remembering auditory presented information, people fixate on blank locations if visual stimuli previously occupied that region of space. It has been shown that such eye movements to nothing can facilitate retrieval of auditory presented information. However, it is unclear which mechanisms underlie the functional relationship between eye movements and memory retrieval. It has been argued that it is not eye movements per se (overt shifts of attention). Instead, covert shifts of attention are sufficient to cause differences in retrieval performance. In order to test this assumption, participants were either allowed to move their eyes or to shift their attention only when remembering auditory presented pieces of information that have been associated to a spatial area during encoding of these information. Indeed, covertly shifting attention towards the emptied spatial area lead to a better retrieval performance then covertly shifting attention away from the associated spatial area. Therefore, covert shifts of attention are sufficient to cause differences in retrieval performance. We conclude that attention plays an important role in explaining the mechanisms underlying eye movements to blank locations.

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The Mind's Eye Revealed by Ocular Tracking

Maryam Fourtassi, Gilles Rode, Christian Urquizar, Yves Rossetti & Laure Pisella
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The study of oculomotor behavior during visual mental imagery (VMI), in patients with impaired mental representations or with visual cortex lesions, might help to understand the potential role of eye movements in VMI and to approach its underlying anatomic substrates.

3 patients with lateral hemianopia, 1 patient with representational neglect, and 10 healthy subjects were asked to name towns they could localize on an imagined map of France, without previous perceptual input, while their eye movements were recorded. Preliminary results: bidimensional regression showed significant correlations between gaze positions and the towns' GPS locations in each healthy subject, but in none of the hemianopia patients and only for the right-sided towns in the neglect patient. Using specific tools developed by geographers, we could identify, for each healthy subject, the generation of iterative small series of towns, mapped with different spatial distortions.

VMI is a dynamic process in which eye movements might play the role of spatial indexes to generate a series of small mental images on a supposedly limited capacity visual buffer. The integrity of the visual cortex might be necessary to this process along with attention pointers to localize pieces of the internal image on this buffer.

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Posters

Decision Making

Monday, August 12, 12:00 - 13:30

Room: Athen (ground floor)

Using eye movement analysis to measure preference structure

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Research Center, Moscow, Russian Federation In preference research, choice predictions based on gaze behavior are usually confined to real-time predictions within single trials (Bee et al., 2006). However, the preference structure is neglected. Thus, decisions in novel choice situations cannot be foreseen. In contrast, conjoint analyses (CA, Green & Srinivasan, 1978) allow for holistic preference decisions to be decomposed into part-worth utilities for each attribute level. Two studies already identified gaze-based preference structures (Glaholt & Reingold, 2009; Pu & MacDonald, 2013). Unfortunately, the authors did not examine concurrent validity for their method. In the current study, we used yogurt packages as stimuli, varying in price, flavor, and fat content. 71 participants solved three tasks to measure preference structure: directly rating value and importance of attributes, ranking yogurt profiles (traditional CA), and repeatedly choosing between alternatives (choice-based CA). Eye movements were recorded during the latter task. For gaze-based preference structure, part-worth utilities were calculated as percentage-fixation time and as an index of preference (Holmes & Zanker, 2012). The identified preference structures differed only slightly between the methods. Finally, the choice of a real yogurt was significantly predicted by all methods but directly rating. Our study underpins the use of indirect methods for preference measurement.

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Gaze bias in two-alternative decisions: effects of stimulus type and decision task

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Prior research has demonstrated that during two-alternative decision making, gaze is biased towards the alternative that is eventually chosen. The Gaze Cascade model proposed by Shimojo, Simion, Shimojo, & Scheier (2003) predicts a larger bias for like decisions than for dislike decisions. More recently, Park, Shimojo and Shimojo (2010) showed that preference formation operates differently during decisions among faces and scenes, which suggests that gaze bias might differ depending on whether the decision stimuli are faces or scenes. In the present study we tested these two hypotheses in a within-subject design. Eye movements were monitored while participants (n=48) made two-alternative like or dislike decisions among pairs of faces or scenes. We found remarkably little influence of stimulus type on gaze bias for either decision task, which disconfirms the hypothesis that gaze bias operate differently for faces than scenes. In contrast, we found that gaze bias was stronger for like decisions than dislike decisions. To further account for this effect we examined the decision time course, which revealed that this task effect is primarily related to biases in the placement, and duration, of the final dwell prior to response. Implications for mechanisms of gaze allocation during multi-alternative decision making are discussed.

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Efficacy of an Eye Movement Training Protocol for Decision-Making in Soccer

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In the first of two studies, participants viewed static images of oncoming soccer players and were required to predict the direction in which they believed the players were about to move. A multiple regression was performed on sixteen eye movement parameters and three demographic variables relating to their motor experiences in soccer, to ascertain their relative contributions to participants' decision making. In a model that predicted more than two-thirds of the variance in decision efficiency, the sole variable that significantly contributed to this variance was the time taken to first fixate the ball. In a second study, two groups of soccer novices viewed the same stimuli as used in Study 1. An experimental group was instructed to look first at the ball; a control group received no instructions. Decision efficiency was superior in the control group, who first fixated the ball later than the experimental group; this suggests that decision efficiency for this task was not contingent on early ball fixation. The limitations of a nomothetic approach to training eye movement patterns are discussed, as is the possibility that parafoveal extraction of configural information reduced the efficacy of such an approach for the present task.

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Visual Fixation Patterns and the Computation of Confidence in Value-based Choice

Chris N. H. Street[1], Catrine Jacobsen[1], Stephen M. Fleming[2,4,5] & Benedetto De Martino[1,2,3]

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Value-based choices (i.e. 'which investment should I make?' or 'what should I eat?') share a number of similarities with perceptual choice (i.e. 'which visual stimulus is brighter?'). However there is a critical difference in the source of uncertainty between these two types of decisions. Contrary to perceptual choice where the goal is an accurate categorization of ambiguous (or noisy) sensory information, stimuli in value-based choice often have little sensory ambiguity. Most of the uncertainty during value-based choice arises from noisy sampling of internal information. For example a decision maker has to retrieve the memory associated with previous experience and integrate it with the current homeostatic state to construct value estimates that will guide his/her choice. We have recently demonstrated it is possible to measure (both behaviourally and neurally) the level of noise in value-based choice using subjective reports of confidence. However, little is known about what drives fluctuation in the noise (measured using decision confidence) during value-based choice. In this study we will test, using eye tracking, how the evolution of visual attentional allocation and fixation duration contribute to subjective confidence in value-based choice. We will also test if attentional allocation post-decision contributes to the fluctuation in decision confidence.

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Study of attention and decision making at the saccade programming in human

Maria Slavutskaya, Victoria Moiseeva, Alekseyi Kotenev, Valeryi Shulgovskyi & Stanislav Karelin
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Behavioral (RT, % of errors) and ERP correlates of attention and decision making cognitive functions have been studied during the saccade preparation. The "double step" (pulse – overshoot) scheme of visual stimulation has been used in 20 subjects. The pattern of saccade response (two or one saccades) depends on the completeness of attention and decision making stages to the moment of second stimulus switching on and on the level of motor readiness and prediction in the period of eye fixation. Both of these factors are reflected in parameters and topography of evoked potentials at the first stimulus switching on and slow negative waves in the period of expectation. In the case of double saccade response we suppose that potential P100 may be EEG-correlate of decision making. Obtained data suggest that the cognitive functions of attention and decision making are realized by fronto-parietal cortical neural networks including ≪top-down≫ mechanisms of saccade control and also fronto-media-thalamic- and thalami-parietal modulating systems. The pattern of saccade responses in double step scheme may be defined by direction of covert attention in the period of expectation.

The study was supported by the RFBR (projects 11- 06 – 00306 and 12-04-00719).

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Bottom-up effects on attention capture and choice

Anne Peschel, Jacob Lund Orquin & Simone Mueller Loose
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School of Business and Social Sciences, Aarhus Attention processes and decision making are accepted to be closely linked together because only information that is attended to can be incorporated in the decision process. Little is known however, to which extent bottom-up processes of attention affect stimulus selection and therefore the information available to form a decision. Does changing one visual cue in the stimulus set affect attention towards this cue and what does that mean for the choice outcome? To address this, we conducted a combined eye tracking and choice experiment in a consumer choice setting with visual shelf simulations of different product categories. Surface size and visual saliency of a product label were manipulated to determine bottom-up effects on attention and choice. Results show a strong and significant increase in attention in terms of fixation likelihood towards product labels which are larger and more visually salient. The observed effect on attention also carries over into increased choice likelihood. From these results, we conclude that even small changes in the choice capture attention based on bottom-up processes. Also for eye tracking studies in other domains (e.g. search tasks) this means that stimulus preparation must be conducted carefully to control for bottom-up effects.

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Disjunction Effect in Prisoners' Dilemma: Testing the Complexity Explanation

Maurice Grinberg & Evgeniya Hristova
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This study explores the disjunction effect in the Prisoner's Dilemma (PD) game. The disjunction effect consists in choosing more often one and the same move (defection) when the opponent's move is known (no matter what this move is) and choosing more often the opposite move (cooperation) when the opponent's move is not known. The experiment was designed to further explore the role of complexity on the appearance of the disjunction effect by manipulating the cognitive load. We are also interested in the information acquisition patterns during playing. Participants played a series of one-shot PD games (intermixed with other games) while their eye-movements were recorded. In half of the games players were asked to sum their payoffs (in such a way the cognitive load is increased). We analyzed choices to check for the presence of disjunction effect. Eye-movement data is analyzed to explore shifts of attention due to the visibility of the opponent's move before the choice is made. The results show that knowing the opponent's move changes the information acquisition patterns in playing PD games – attention is shifted to the payoffs corresponding to the opponent's choice.

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Posters

Dyslexia

Monday, August 12, 12:00 - 13:30

Room: Stora salen (2nd floor)

The influence of blur and accommodative stress in eye movement measures in non-reading tasks

Gro Horgen Vikesdal[1,2], Stuart J. Gilson[1], Trine Langaas[1]
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Eye movement recordings are frequently performed in studies of dyslexia and reading disorders, and it is often reported that sufferers have abnormal eye movements. In reading tasks, dyslexics have longer fixations, spatially-shorter saccades and more regressions. In non-reading tasks, dyslexics may have abnormal saccadic latencies and less accurate fixations. Studies frequently do not discuss if patients have normal vision and accommodation. We speculate that the abnormal eye movements observed could be partially attributed to blur or accommodative stress and that such abnormalities could be equally found in normal readers if blur or accommodative stress was induced.

The purpose of this study was to investigate the effect of blurred vision and accommodative stress on eye movement measures. Adults with normal visual function performed a selection of fixation tasks, while their eye movements were recorded using a video-based eye-tracking system with a sampling frequency of 120 Hz. The experiment was repeated with various lenses to introduce blur or accommodative stress and abnormal eye movements were recorded that are comparable to those observed in dyslexics. Based on the study results, we propose guidelines for the use of corrective lenses in eye movement studies to avoid contaminating the results

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Lexical access in slow readers

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During reading, dyslexic readers exhibit shorter forward saccades, they skip very few words, fixate many words multiple times and exhibit prolonged fixation durations compared to typical readers. Hawelka, Gagl and Wimmer (2010) interpreted the short forward eye movements of dyslexic readers, their tendency to fixate the beginning of words and the many instances of multiply fixated words as enhanced reliance on sublexical decoding. However, even when the dyslexic readers fixated a word only once which was interpreted as reflecting direct lexical access, then these single fixations were also abnormally prolonged. The present study (with 32 adult slow readers and 35 typical reading controls) investigated by the means of ex-Gaussian modelling and survival analysis of fixation durations whether this prolongation can be attributed to slow activation of orthographic whole-word representations ("familiarity check"; indexed by the effect of word frequency) or, alternatively, to slow lexical completion (i.e., access to meaning from instantiated orthographic representations; indexed by the effect of word predictability). The preliminary findings indicate that slow readers are in principle capable of quickly activating orthographic whole-word representations, but are slow in lexical completion.

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Phonological Processing During Silent Reading in Children with Dyslexia

Jonathan H. Dickins, Hazel I. Blythe, Colin R. Kennedy & Simon P. Liversedge
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Phonological processing is a key aspect of reading, and there is evidence to suggest children with dyslexia have deficits in this area. Eye movement research has shown that skilled adult readers use both phonological and orthographic information to identify words during silent sentence reading (Rayner, Pollatsek, & Binder, 1998). Such effects have not, to date, been examined in children (either with or without dyslexia). We recruited two participant groups: Typically developing children and children with dyslexia. These groups were matched on age and IQ, but differed in their offline reading assessments. We recorded their eye movements as they read sentences containing three types of target words: Correct words (e.g. church); pseudohomophones (e.g. cherch); and orthographic controls (e.g. charch). We simultaneously manipulated the visual similarity of the pseudohomophones by varying the number of letters that were changed from the correct word to form the pseudohomophone (this was matched in the corresponding change to create the orthographic control). We predicted faster reading times on pseudohomophones relative to orthographic controls in our typically developing participant group, given the robust nature of such effects in adult readers. Given their phonological processing deficit, however, we predicted no such difference in our participants with dyslexia.

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Eye-tracking in typically developing adolescents with different reading skills

Katrin Daniela Bartl-Pokorny, Florian Pokorny, Thomas Wolin, Peter B. Marschik & Christa Einspieler
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Objective: Previous studies on reading development reported differences in eye-movement-patterns in adolescents with normal reading skills compared to individuals with dyslexia. Here we aim to assess a potential association between eye-movement-patterns and reading competence in normal readers and adolescents with moderate reading difficulties.

Methods: Twenty-three typically developing Austrian-German speaking adolescents (14 girls, 9 boys) participated in a comprehensive longitudinal study focusing on neuromotor, cognitive, and speech-language development. For the purpose of the present study we assessed reading competence with the Reading-Speed-and-Reading-Comprehension-Test (LGVT; Schneider et al. 2007) at the participants' age of 13;6 (years;months). Based on their LGVT percentile ranks (PR) participants were divided into three groups: "skillful" (PR$\geq$85), "average" (PR 21-84) and "below-average" (PR$\leq$20) readers. We then used a 500Hz SMI-iViewX-HiSpeed device to assess their eye-movements while reading a text.

Results: We observed group differences in amount and amplitude of saccades as well as total fixation duration per word. No differences were found in average fixation duration, duration of the first fixation on a word, or number and percentage of regressions.

Conclusion: Variations in eye-movement-patterns might be associated with different reading competence levels. However, further research is needed to confirm these findings as a general fingerprint of adolescent literacy skills.

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Ophtalmokinetic Differences Between English Dyslexic and Aged Matched Normal Readers During Reading

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The severe reading difficulty is the fundamental diagnostic criterion of dyslexia and is best reflected in their ophthalmokinesis.

Of the 18 participants (10 years 2 months to 14 y. 7 m.), 9 were normal readers and 9 were dyslexics, who were 3 years behind in reading. The text difficulty was equaled not to their chronological but to the average reading age of each group. While they read silently, their ophthalmokinesis was recorded with a photoelectric method with a horizontal accuracy of .25° and a time resolution of 4 msec.

Their data were analysed with one-way ANOVA and dyslexics exhibited significantly worse performance than the normal readers in most of their ophthalmokinetic characteristics. The most striking difference between the two groups was in the number of regressions / 100 words ($p<0.000$) and there was no overlap between the two groups. The 2nd most significant difference was in the perceptual span ($p<0.0002$).

A plausible explanation of the dyslexic's erratic ophthalmokinesis is that it reflects a more general biological disability, that of sequential order.

Pavlidis, G.Th. (1981). Do eye movements hold the key to dyslexia? *Neuropsychologia*, 19, 57-64.

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Saccadic behavior in children with dyslexia and ADHD during reading

André Krügel[1], Angela Ines Klein[2], Günter Esser[1] & Ralf Engbert[1]
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Reading depends on the effective control of rapid eye-movements, which move words into the fovea. According to a recently proposed Bayesian model of saccade planning optimal oculomotor behavior is based on the integration of current sensory information and non-sensory prior knowledge learned through past experience (Engbert & Krügel, 2010, PsychSci). The present study aims at assessing the oculomotor behavior of dyslexic children, children with an attention-deficit/hyperactivity disorder (ADHD) and healthy children during reading. Eye-movements were recorded while the children read two short text passages. We found that the two clinical groups show unique oculomotor characteristics. Dyslexic children show an increased tendency to make multiple fixations on words (refixations) and less word skipping as compared to the other groups. Furthermore, they exhibit a strong tendency to initially fixate at the beginning of words. Children with ADHD show in the main comparable target-word selection rates to the healthy control group, but move their eyes further into the words. Even more interestingly, children with ADHD further show substantially increased landing-position variability within words, suggesting that the computations of saccade target positions within words are less reliable for these children. The results are discussed in relation to our Bayesian model of saccade planning.

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Posters

Educational Applications

Monday, August 12, 12:00 - 13:30

Room: Stora salen (2nd floor)

The text-diagram arrangement effect on science learning: Analyzed through eye movement indicators

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The study investigates whether left-right arrangement on learning science materials would have impact on high school students' performance. Twenty-three students were randomly assigned to two groups (left-text/right-diagram and right-diagram/left-text). Materials consist of two slides describing the human circulatory systems and how it works. Off-line measurement of post-test performance and on-line behaviours of multiple eye movement indicators were analysed through two-way ANOVAs (arrangement x AOI). The result between groups indicates insignificant arrangement effect on post-test and on all eye movement indicators. For slide 2 (on system function), the arrangement effect was not found; however, participants firstly fixated longer on the word section than the diagram area (first run dwell time, first run fixation count, proportion of first run fixation, all ps<.05). Moreover, the participants have more fixations on words than the diagram (dwell time, fixation count: ps<.001). In sum, the data shows the words and diagram arrangement introducing heart components and function of the circulatory systems brought the result of insignificance on learning performance and eye movement indicators. However, the profound finding was demonstrated when participants read the functions of the systems; they had more focus on words than the diagram. The results could contribute to science textbook design.

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Eye movement when solving geometry problems

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The study investigates: (a) whether eye movement patterns are different between successful solvers and unsuccessful solvers and (b) whether eye movement is sensitive to perceived difficulty (measured by a cognitive load scale). Fifty seven 11th graders solved five geometry problems selected from the previous experiment. Participants used a digital drawing tablet and sensitive pressure pen to calculate and input answers. The result indicates more duration and fixation points on question area but less on answer area as the problem becomes harder. Unsuccessful solvers gain more dwell time and fixation count on question area but less on answer area. Moreover, unsuccessful solvers have more regressive behavior in question area. In sum, difficult problems would make participants pay more attention to question area instead of answer area. Besides, fixation count and dwell time of both problem and answer areas are sensitive to the changes of difficulty only when problems are difficult (pass rate= .37) and run count within the problem areas is sensitive to the change of difficulty as well. In this study, the findings suggest some sensitive eye movement indicators and eye movement approach are quite promising for future research on researches of on-line cognitive processes.

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An eye-tracking study of how children integrate text and picture in processing an illustrated expository

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Hegarty and Just (1993) found that college students using text-directed approach to comprehend illustrated texts. The current study examine whether children taking similar reading strategies to integrate text and picture in processing an illustrated text. Each text included two pictures. The first one was a decorative and the second picture was explanative. If children used "text-directed" approach to processing texts, they will pay longer reading time to explanative picture, because explanative graphic was higher cohesion to text. Forty 6th graders' online processing of text and pictures during reading two illustrated expository texts was recorded. Results of a cluster analysis using indices of run count revealed two patterns of visual behavior varying for the level of integration of text and pictures. Both of two integrated group spent longer reading time to the explanative picture than to the decorative picture. Considering the group effect, the higher integrated group spent longer reading time on the picture area than those of lower integrated group. However, both of group spent similar reading time to the text areas. This result implied that the ability to select main idea from picture may play an important role to guide children how to integrate text and picture representation.

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Just for Kids - classroom appropriate reading eye movement examination system

Pawel Czarnecki & Jan Ober
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Eye movements which accompany the reading has been accepted as an objective biological signal describing entirely and exhaustively the process of acquiring lexigraphic information. Regrettably there has not been found yet a wide application in monitoring of disturbed acquisition of reading skills by children. Two factors are responsible: lack of adequate instrumentation and proper methodology, allowing to evoke consistent reading conditions in regard to accuracy of word decoding and precision of understanding. Without this the reading is vulnerable to variations, making the reading eye movement parameters inconsistent. Authors present novelty experimental setup where the reading is evaluated independently in two dimensions, efficacy of word phonological decoding and reading with comprehension, which is controlled online based on isolating sentences written as a continuous string of words. The lexical processing is observed on two levels, microdecisions involved in saccadic scanning and macrodecisions related to disambiguation of word pairs, written without the space in between and the isolation of meaningful sentences. The macrodecisions are detected by means of reading pen which pick-ups instances of drawing lines, while disambiguating the word pairs and drawing the line separating sentences. Eye movements are recorded by the dedicated infrared reflection system eliminating the necessity of individual adjustments.

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Students' Gaze Reveals Option Preferences in Multiple-Choice Assessment

Marlit Annalena Schmidt, Gun-Brit Thoma & Olaf Köller
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People have a tendency to fixate objects they like or prefer. Findings in basic and applied decision research reveal a reliable shift in attention towards chosen options – prior to actually being chosen. We investigated this gaze bias effect in the applied educational context of multiple-choice (MC) items, exploring the predictive potential of eye fixations for students' answer option preferences. Groups of expert (n = 14) and lay students (n = 12) worked on a 21-item MC-test (four options per item) while their eye movements were recorded. An increase in total dwell time occurred in a monotonic manner for options with higher rated subjective preference (three categories), independent of expertise level. An adapted gaze likelihood analysis gives insights into the item solving process referring to option preference categories and students' expertise. This analysis reveals that attention for chosen options increases over decision time, while fixation probability reaches a maximum just prior to the response in both expertise groups. Furthermore, data account for the capability of total dwell duration on MC options to uncover persons' test domain knowledge, by relating eye movement data to objective criteria of answer correctness. Implications for educational applications in the field of MC-test development are discussed.

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Advantages of word and diagram in describing configuration representation of a mechanical system: Evidence from eye movements and comprehension tests

Yu-Cin Jian & Chao-Jung Wu
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This study investigated whether readers are able to form internal representations of a mechanical configuration described by a written text. Sixty-three undergraduate participants took part in this study. We employed a two-stage procedure: participants first read the mechanical configurations, which consisted of text or a diagram and then read text describing kinematic information of the same system. Their eye movements were recorded while reading. Participants were assigned to one of three groups (configuration, non-configuration, or diagram). The results showed that the configuration group had higher configuration test scores than the non-configuration group; the configuration test scores regarding local connective relations were also higher for the configuration group than for the diagram group. However, on the global dimension of the same test, the diagram group performed better than the configuration group. In our analysis of eye movements, the configuration group displayed shorter total fixation durations and rereading times of the kinematic text than the non-configuration and diagram groups did. We argue that readers were able to form a mental representation of the mechanical configuration described by written words. Advantages of the text and diagrams are describe local connective relations and global analogical relations, respectively, within the mechanical system.

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Eye-movements as a marker for cognitive processes in reading comprehension: A study with 6th-graders

Markus Eichner
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Researchers have gained much knowledge about oculomotor control and visual processes in reading. In general, poor readers make more and longer fixations per row. Never the less the role of eye-movements in reading comprehension, reflecting cognitive processes, is, at best, unclear.

For a better understanding, I examined eye-movements of 78 German 6th-graders reading two texts taken from a standardized test. As expected the high school students (Gymnasium) outperformed the secondary school students (Hauptschule) in reading comprehension. This was accompanied by shorter mean fixation times for high school students. Moreover students with a large working memory capacity and longer gaze duration showed a poorer understanding compared to students with a similar capacity but shorter gaze duration, even when controlled for their vocabulary. Thus, longer gaze duration in good readers indicated problems in cognitive information processing in the sample. A compensating effect of longer gaze durations for readers with a poor working memory was not observed. The findings show how important reader's characteristics are for a successful interpretation of eye-movements as a marker for cognitive processes in reading comprehension. Results are discussed further in the light of reading socialization.

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How students with different prior knowledge regulate their learning process in a computer-based environment: An eye tracking study

Loredana Mihalca[1], Christoph Mengelkamp[2] & Wolfgang Schnotz[1]
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Computer-based learning environments (CBLEs) allow students to actively regulate their learning process, and hence to improve their performance. However, research has revealed that many students do not benefit from CBLEs, because they either lack the needed self-regulatory abilities or do not use them properly. To investigate how students with different prior knowledge regulate their learning in a CBLE consisting of several genetic problems, participants' eye movements were recorded. In the CBLE, the genetic problems were presented in a fixed, predetermined simple to complex sequence designed according to the 4C/ID model (van Merriënboer, 1997). Performance, cognitive load measures, and eye movement data were obtained from 63 university students. It was expected a positive relationship between prior knowledge and the number, and duration of fixations, as well as the number and duration of visits on different areas of interest (AOIs). In addition, it was expected that students' eye fixations would be related to the performance, time-on-task, and cognitive load measures. First results indicated that prior knowledge is related to the number and duration of fixations, as well as number of visits. We discuss the implications of these results for self-regulation learning (SRL) in general, and for SRL in CBLEs in particular.

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How to improve learning from video, using an eye tracker

Jelle de Boer
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Video is increasingly used as an instructional modality in education. Therefore it becomes more important to improve the learning process of students from video lessons. Sometimes, the only way to interact with the video is through the control buttons of a media player. This gives students only a few standard options to interact (start and stop) with the video, hardly supporting the learning process of students.

In our experiments, we used an eye tracker to test a new model that addresses both the stylistic and strategic components of students' viewing behaviors. We applied this model on a group of 115 students to see whether the learning effects differ among students with different viewing behaviors.

Results show that learning from video can be improved in some areas. One of them is improving the videos itself. We will present some guidelines in the oral presentation. Moreover, the integration with the learning tasks of a student can be improved. Some examples - recorded with an eye tracker - will be shown of viewing and learning behaviors.

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Reading behaviour in dynamic scenes and the processing of subtitled academic lectures

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North-West University, South Africa

The fact that subtitles form part of a dynamic text/scene that imposes certain time limits on the reader/viewer means that this form of reading cannot be studied in exactly the same way the reading of static texts is studied. Although eye tracking measures such as fixation count, dwell time, revisits, and regressions present an index of the amount of attention subtitles receive, they do not as such provide us with a nuanced index of the degree to which the subtitles were actually read. Before we can make any confident statement on the impact of subtitles on comprehension, language acquisition, and cognitive load, reading behaviour has to be quantified. In this presentation we will present a validated index for measuring reading behaviour in dynamic scenes, based on weighted fixation count and saccade length, word length in characters and word length in pixels. We will then present the findings of a study on the processing of subtitled academic lectures making use of this index. Here the focus will be on determining whether the extent to which viewers read subtitles in the context of same-language English subtitles, has an impact on comprehension.

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Teachers' visual attention and student motivation during lectures

Rob Klassen[1], Richard Remedios[2] & Nora McIntyre[1]
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This presentation reports results from two studies examining the relationship between teachers' visual attention and student motivation.

In Study 1 we manipulated the amount of visual attention (high = 50.6 %; low = 2.7 %) given by a teacher to two randomly assigned groups of students (n = 16 per group). Visual attention was measured with a 30-Hz head-mounted mobile eye-tracker (Tobii). Outcome data included student self-efficacy, content knowledge, and boredom. Gaze fixation target and duration were measured.

Study 2 data will be collected in April 2013, and will focus on (a) replicating Study 1 findings and (b) exploring the relationship between teacher visual attention and student reciprocated gaze, with students wearing point-of-view video eyeglasses.

Results from Study 1 showed a significant effect of visual attention on self-efficacy, d = 1.21 and content knowledge d = 1.34 with the effect (surprisingly) favouring the low attention condition.

Theoretically, visual attention should promote enagement (e.g. boredom), motivational outcomes (e.g. self-efficacy), and performance (e.g. content knowledge). Results from Study 1 suggest that visual attention from unfamiliar teachers does not promote increased motivation and learning suggesting that social familiarity may modulate the cognitive processing of visual attention.

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How image content correlates with image perception

Jana Holsanova[1], Helena Sandberg[1], Nils Holmberg[1] & Nelly Theobald[1,2]
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Newspapers contain various images that illustrate news articles: photographs, maps, drawings, diagrams, etc. However, very little is known about how readers interact with these images. Which types of images get most attention? Which image contents are attended to most by the readers?

We investigated how image content correlates with image perception. First, we created a coding scheme and conducted a content analysis of the images, with a substantial intercoder reliability. Second, we formulated hypothesis about reader interaction with these images. Third, we matched data from the content analysis with a database containing eye movement data from the readers' authentic interaction with these pictorial elements. Fourth, we conducted a linear regression analysis on how the different variables would predict dwell time on images.

The regression analysis on picture type revealed that information graphics was associated with significantly longer dwell time than photographic pictures ($p < 0.05$). The regression analysis on picture content revealed that pictures containing children was associated with significantly longer dwell times than pictures without children ($p < 0.05$). Contrary to our expectations, we found tendencies that readers looked longer on pictorial elements with inanimate than with animate content, and longer on pictorial elements with static than dynamic sceneries.

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Effect of Expertise On the Perceptual Categorisation Process in Sport (Contribution of Simulation Technology)

Mohamed Sebbane
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This study has as its main object to show the effect of categorization of the configurations of play in football. According to Mervis and Rosch (1981), the category is an organization which makes it possible to gather various physical objects or concepts in the same class. This many make us suppose that the elements (i.e., specimens) of the same category have physical features (perceptual) or conceptual (concept) similarities. The main results of this study show, on the one hand, that the experts acquire a rich person repertory of conceptual knowledge by the practice and the experiment and the other hand, through the process of the activity that facilitates the visual data. This operating process of the expert system reduced considerably the space of research. This generally results in an effective and a rapid cognitive performance.

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Directorial Assumptions, Depth of Field Effects in Moving Images and Oculomotor Behavior

Dimitrios Sarakatsianos
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Film making practitioners utilize depth of field effects with the aim to modulate the viewers' attention [Carroll, N. (2003). Engaging the Moving Image, Yale University Press, pp. 10-58], but their knowledge is intuitive, tacit and experiential in nature. Contemporary vision research conceptualizes visual attention through a number of different concepts: Overt vs. Covert Attention, Top-down vs. Bottom-up Attention, Number of fixations, Fixation Duration, Global vs. Local Spatial Distribution, Scan Path theory [Norton, D. and Stark, L. (1971). Scanpaths in Saccadic Eye Movements While Viewing and Recognizing Patterns. Vision Research 11, pp. 929–942.]. Cognitive Film Theory offers a number of interesting perspectives in relation to visual attention and moving images (Smith, T. J. (2010). Film (Cinema) perception. In E. B. Goldstein (Ed.) The Sage Encyclopedia of Perception). Using a specific cinematic device (i.e.: Rack Focus), often employed by film making practitioners as a technique to modulate attention we examine if the technique's effect as measured by mean fixation counts confirms practitioners' intuition. We examine if statistics for fixation counts can be used to detect differences in oculomotor behavior of viewers. We discuss mathematical techniques that can be used to examine visual attention's shifts during viewing moving images.

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Navigating through hypertext. Do gender and type of navigational support matter?

Jaap Walhout, Saskia Brand-Gruwel, Martin van Dijk, Halszka Jarodzka, Renate de Groot & Paul Kirschner
Open University of the Netherlands

Since hypertext learning environments (HLE) are widely used in education, it is important to study the effects of its use. Earlier research suggests that learning outcomes based on hypertext environments depend on learner characteristics in conjunction with hypertext specific features. In this eye tracking study one user characteristic (gender) and one hypertext feature (navigational support) were investigated. Navigational support was varied by using a tag cloud as navigation structure or a hierarchical menu. Results showed no difference in gender or navigational support regarding task performance. However, participants using a tag cloud, looked considerably longer at the navigation structure. The longer fixation times might be due to participants' deeper elaborations of the tag cloud or their unfamiliarity of using a tag cloud interface. Furthermore, page revisits were significantly lower in the tagging group. Although not significant, users of a hierarchical menu visited more unique pages and pages overall. These findings indicate that using tags results in more effective pages selection. As there was no difference in time on task and no differences in task performance it can be concluded that using tags as navigational support does not hamper performance compared to hierarchical navigation structures and might be more effective.

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Posters

High Level Reading

Monday, August 12, 12:00 - 13:30

Room: Stora salen (2nd floor)

Dynamics of homonymous word processing: Visual world paradigm applied

Gabriela Peykovska & Armina Janyan
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An experiment using visual word paradigm was conducted to trace online activation of meanings of homonyms. Four printed words (dominant meaning of a homonym, subordinate one and two control words for each meaning) were presented to the participants on a Tobii eye tracker screen. On the first second after appearance of the four visual stimuli, a homonymous word was presented aurally through the headphones. Participants had to decide whether the auditory presented stimulus had anything meaning-related with any of the visually presented words. Time course of meaning activation showed different activation levels during three main time windows of stimuli processing. In the first 800 ms after the aural stimulus offset, strong activation of control words appeared, followed by a subordinate meaning activation. The last time window showed progressively increasing activation of dominant meaning and decreasing activation of other meanings (subordinate and control ones). The initial leading activation of control words was interpreted as an additional conscious re-checking of inappropriate words, probably aiming their further suppression. Overall, it seems that the results point to attentive processing of the words' meanings due to their pre-activation from viewing the stimulus display before the offset of the target homonym.

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Spontaneous re-reading of structurally ambiguous sentences: Eye movement behaviour and visual sampling

Laura M. T. Lantz, Sarah J. White & Kevin B. Paterson
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Considerable research has been undertaken into the mechanisms underlying forward reading, but little is known about the mechanisms underlying spontaneous re-reading. Recent work has indicated that visual re-sampling during re-reading within sentences is not always necessary (White, Lantz, & Paterson, 2012). The present study further examined whether the need for visual sampling during re-reading is modulated by sentence difficulty, and how text availability during re-reading impacts on eye movement behaviour. Temporary structural ambiguity within sentences has been shown to be associated with a greater likelihood of regressions and re-reading (Patson, Darowski, Moon, & Ferreira, 2009). The present study therefore employed sentences that were either ambiguous (in the absence of a comma) or disambiguated by a comma, for example 'While the man hunted(,) the deer that was brown and graceful ran into the woods.' A contingent change methodology was used such that all words more than one word to the left of fixation were either masked with visually similar letters (to prevent re-sampling) or remained present. Overall reading times, as well as global and local eye movement measures, will be presented alongside comprehension rates. The theoretical implications will be discussed in relation to models of eye movement control during reading.

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Why spaces should be replaced by hyphens in English compounds

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[3]McMaster University, Canada

In the current study English natives were exposed to English compounds in a spaced and hyphenated variant. The compounds were presented in sentence context and strongly biased towards the spaced variant (credit card). The results showed that nevertheless presentation format did not yield a difference in gaze duration. In fact, sentences were read faster with the compound in hyphenated than in spaced format. Moreover, there was an interaction between presentation format and trial number in total fixation duration, reflecting that in the course of the experiment only hyphenated compounds elicited increasingly faster total fixation durations. This resulted in shorter total fixation durations for hyphenated than for spaced compounds by the end of the experiment. These results are in line with those of Staub et al. (2007), who found that in processing long spaced compounds, the first constituent is typically misanalyzed as the head of a noun phrase. The current study is also in line with Bertram et al. (2011), who showed that in Finnish the hyphen does not introduce this kind of ambiguity. In the light of this study it seems curious that some 16,000 hyphenated compound words were eliminated from the newest edition of the Shorter Oxford English dictionary.

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The effects of causal and anaphoric connections on children's text processin

Wanshin Chang[1], Chiung-hsien Tsai[1], Minglei Chen[2] & Yuhtsuen Tzeng[1]
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Causal connections and referring expressions play a fundamental role in forming a coherent representation for reading comprehension. The purpose of this research was to use eye tracking techniques to unfold how grade 4 to 6 readers resolve those relations during comprehension. Since zero pronoun sentences were grammatical in Mandarin, we were able to manipulate causal (high or low) and anaphoric (zero or overt) relations between two consecutive sentences in a short text simultaneously. A third sentence was used to tap readers' comprehension. As a result, a 2x2 design was adopted. Thirty-six experimental texts and 18 fillers in randomized order were implemented in Experiment Builder. As expected, our analysis revealed no effects for both causality and anaphor in the first gaze duration of the first sentence because no experiment manipulation applied there. In the second sentence, the analysis revealed participants generated significant differences in the first gaze duration and first-pass backward duration in causality and anaphor. The results also showed participants invested more processing time for texts with weak than strong causal connection, and with zero than overt anaphor. The overall patterns suggest when reading texts with strong causality and appropriate anaphor can help young readers build effective coherence.

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Eye movements during reading controversial socioscientific texts

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In the modern society, it is important to understand socio-scientific issues (SSI) about the impact of science and technology on human life and environment. In this study, participants were provided with a 2000-word text about power generation (including nuclear, solar, wind power, and fossil fuel) and the pros and cons of them were discussed regarding the resource, environmental, and socioeconomic aspects. Participants were instructed to read to argue against the usage of nuclear power with their eye movements being recorded. After reading, their argument was assessed by interview. The preliminary results showed that participants tended to spend more time on sentences about nuclear power (which confirmed the perspective effect, demonstrated by Kaakinen, Hyönä, & Keenan, 2003), especially those describing the advantage of it. The pattern of results was more prominent during late processes (such as total viewing time and rereading time) than during first pass reading. Contrary to the prediction related to myside bias (i.e., focusing on supporting evidence while ignoring others), the participants paid attention to counterarguments (i.e., the advantage of nuclear power) at least during rereading. This finding may shed some light on the cognitive processes during informal reasoning on SSI.

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The Role of Saliency and Expectation in Sarcasm Processing

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The present research uses eye-tracking while reading to discriminate between two leading cognitive theories of irony processing: the Graded Salience Hypothesis (GSH) and the Implicit Display Theory (IDT). These two theories make different predictions with regard to the influence that two factors (saliency and explicitness of speaker's expectation) will have on the comprehension of verbal irony, or sarcasm. The GSH predicts that highly familiar (salient) sarcastic comments should be processed in equal time to their literal counterparts, while unfamiliar (non-salient) sarcastic comments should take longer to read than literal ones, independent of whether the speaker's expectation was made explicit or implicit in the context. On the other hand, the IDT predicts that when the speaker's expectation is explicitly stated in the context, then sarcastic comments should take less or equal time to process compared to literal ones, whereas when the expectation is implicit, sarcastic comments should take longer to read, independent of their saliency. Therefore, finding that reading times are primarily influenced by saliency would support the predictions of the GSH, whereas finding that expectation is a more important cue would support the IDT.

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Attention distribution during source code reading

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Code reading is an essential process during writing and maintaining software and represents the fundament for program comprehension. The better we understand these processes, the better we can support novices to master the difficult task of programming and assist programmers in developing software. Program text is a special type of text, since it's highly structured and executable by a computer.

We conducted a study on code reading using a combination of eye tracking and retrospective think aloud in order to learn more about the characteristics of reading code by comparing natural-language text and source code. Fifteen subjects were examined and completed a questionnaire about their programming skills, ranging from novice to expert in several programming languages.

The comparison between mean fixation durations in natural-language text and source code showed a significant prolongation during code reading, indicating a substantial increase in cognitive load for both novices and experts. Furthermore, fixation times on different lexical Java elements were analyzed to examine how novices and experts distribute their attention. This is of interest, since the word pool for certain elements like keywords is very limited, and should therefore be very familiar to experts, while other elements, e.g. identifiers, can be chosen rather arbitrarily.

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Emotional Word Processing and Grounding Second Language Semantics: An Eye Movement Study Of Reading

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Introspective data suggest that emotional word processing is reduced in a second language (L2) compared to a first language (L1), though few studies have examined whether language proficiency modulates L1 vs. L2 emotional word processing. Drawing on an embodied approach, we examined interactions between emotional, sensorimotor (concreteness), and linguistic (lexical frequency) information for target words embedded in sentential contexts, using data for 34 native French speakers reading in English (their L2), which were compared with prior data for 43 native English speakers reading the same materials in their L1 (Sheikh & Titone, accepted). Early-stage eye movement measures showed that L2 reading was faster for positive words that were abstract, high frequency words, and concrete words. This contrasts with our prior results from L1 readers for whom reading was faster for negative and positive words that were abstract, and concrete words that were emotionally neutral, a pattern of effects that was limited to low frequency words. Interestingly, higher L2 proficiency predicted faster processing for concrete words but not processing for emotional words. These findings suggest that L2 readers are less sensitive to the emotional charge of negative but not positive words, which could arise from reduced exposure to negative L2 contexts.

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Tracking readability in eye movements

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This project aims at identifying differences in reading behavior in subjects reading normal, simple and non-sense sentences. It is expected that comparison of reading behavior on carefully matched parallel sentences can shed light on how the notion of readability affects reading behavior. The planned project design involves 25 subjects and 900 test items, 300 each of the three types, normal, simplified and non-sense. A smaller pilot study will guide the final project design development. We will examine differences in reading behavior as measured on a range of standard eye movement metrics in reading, including number and duration of fixations, regressions and speed (Holmqvist et al., 2011) as well as correlations between known indicators of readability level, including word- and sentence length, word frequency and language model perplexity (e.g. Schwarm & Ostendorf, 2005). The normal and simplified sentences are selected from a corpus of parallel simplified and normal news wire (Klerke & Søgaard, 2012). Subjects will be experienced readers, and standard tests of reaction speed, reading speed and working memory capacity will also be administered. Identifying readability differences manifesting similarly across subjects could help predict readability to the benefit of automatic detection and generation of texts for reading impaired individuals.

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Linear Relation between Information Content and Reading Time: Counter-Evidence from Eye-Movements

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Spoken language research (Piantadosi, Tily & Gibson, 2009, 2011) suggests that lexical systems achieve optimality with respect to conveyed information, if the time taken to process a word is linearly related to its information content. We conducted a sentence-reading experiment where the information content of a target word was based on an n-gram model trained on Google's "English One Million" corpus. We observed that early and consolidating eye movement measures do not reflect the expected linear relationship between information content and processing time of the target word. Based on the same experimental data we also investigated reading behavior for semantic context wider than a syntactic n-word neighborhood. When a context with scope wider than an n-word neighborhood was analyzed, a different trend was observed. A target word was processed faster in lower information content sentences, i.e., when target words were embedded in a predictive context, than in higher information content cases, i.e., when target words were embedded in neutral context. The combination of these results suggests that the influence of lexical factors on reading time cannot directly be transferred from the domain of spoken language to the domain of reading.

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Sex differences in visual processing and recall performance of text

Halszka Jarodzka[1], Renate de Groot[1], Rudolf Ponds[2], Wim van der Elst[3] & Paul Kirschner[1]
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Large scale studies showed that girls outperform boys in verbal abilities that are often captured with written tests. This raises the question whether girls and boys process written text differently. Therefore, we compared 23 girls and 32 boys (age 14-15 years, Dutch) in a standardized story recall test. They read one page of text while their eye movements were recorded. Afterwards, they recalled as many details as possible. In this cohort, boys outperformed girls. Eye tracking showed that girls had higher saccadic amplitudes and velocities, and that their fixations were more dispersed compared to boys. Thus, girls were less focused in studying this text than boys. Moreover, eye tracking per text paragraph reveled that girls had more fixations and a longer total fixation time on the first third of the text than on the last third of the text. Boys showed the opposite results pattern. Moreover, girls revisited the first paragraph more often than boys. Thus, girls stick to the beginning of the text, while boys read the entire text. These findings show that girls and boys process written text differently resulting in different recall performance. However, the nature of these sex differences might depend on the specific cohort investigated.

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Effects of four electronic text presentation formats on reading efficiency and comprehension

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A primary goal within the reading curriculum is the ability to read fluently and with good comprehension. Though reading practice has a long-standing tradition, instructional methods to achieve such goals have varied widely. Technology has introduced opportunities for new and enhanced instructional approaches. Yet prior to this investigation, no studies have explored the instructional impact of text presentation formats on reading development using current technology. This study's goal was to determine whether the exposure to a particular text presentation format as part of a 40 fifteen-minute lesson treatment resulted in the same or different development gains achieved by fifth-grade students.

A stratified, randomized experimental research design was used to examine the causal relationship between four text presentation formats and three reading achievement variables (comprehension and silent/oral reading efficiency). The four formats that were analyzed included: static passage display, passage build-up display, line-by-line display, and moving window format.

All treatment groups achieved significant performance improvements as a result of reading 40 appropriately leveled text passages utilizing one of the four text presentation formats. Despite substantial comprehension improvement mean differences, no statistically significant differences were detected between the four group means. Efficiency measures revealed statistically significant differences among the groups.

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Recording Gaze Over Canned Subtitles: Technical and Methodological Considerations

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In this talk we will present lessons learned from two studies of segmentation of pre-rendered subtitles in film. Both studies failed to show statistical significance of syntactically incoherent segmentation of subtitles. In the first study, regardless of the quality of line segmentation, viewers were able to understand the Hungarian film content (Italian subtitles), both in terms of scene and word recognition, and no tradeoff between processing of text and scene was observed. In the second study, designed to simulate the first (but with English subtitles), eye movements were analysed following their capture while viewing the same film clip. Four types of subtitle segmentation were used: syntactically coherent, syntactically incoherent, pyramidal (top line always shorter than the bottom), and segmented word-for-word (simulating live subtitles). Although significant differences were expected in gaze crossovers between scene and text among viewing conditions, none were detected. We will discuss technical challenges in capturing gaze over video as well as methodological issues that we think may have impacted study results.

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Reading a novel in your second language: A comprehensive eye tracking study

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Models of eye movements during reading exclusively focus on monolingual reading, even though the majority of people are bilinguals. Until now, few studies examined eye movements in bilinguals and none investigated bilingual sentence processing. They examined eye movement measures on a single embedded target word without taking into account changes in global eye movement behavior (e.g. average saccade length) that L2 reading might entail.

This project assesses differences between native language and L2 reading. We examine a large scale data corpus that we collected from 19 Dutch(L1) – English(L2) unbalanced bilinguals of intermediate to high L2 proficiency. Participants read an entire novel, half in Dutch, half in English, while their eye movements were being tracked.

Sentence reading times of matched translation equivalent sentences were fitted within a linear mixed model. L2 reading times were longer than L1 reading times, controlling for average word length and number of words per sentence. We obtained clear interactions of multiple lexical variables with language, irrespective of language density differences between English and Dutch. For example, an extra word per sentence slowed down sentence reading times, but even more so when reading in L2.

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Left eye and right eye in reading left-to-right and right-to-left orthographies

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There is mirror symmetry about the median sagittal plane with regard to the anatomical plans of the eyes, the surrounding musculature, and the cortical and subcortical visual pathways. However, there are critical cortical asymmetries in language functions and in the broader processing styles of the two hemispheres, in the typical brain. There is also directionality within words and within sentences on the page, typically right-to-left or left-to-right. Requiring the two eyes to move more or less in tandem across a page of text may mean that one eye assumes a dominant role in general, or at any one time. We report data from left-to-right and right-to-left languages in the Edinburgh 5-Language Corpus, with regard to differential behaviours of the two eyes both within and between fixations, and relate them to a broader theory of binocular fixation in reading (Shillcock, Roberts, Kreiner, & Obregón, 2010).

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Modelling font effects in word recognition with a liquid state machine

Patrick Hynes & Ronan Reilly
NUI Maynooth, Ireland

This talk will present an application of a computational model of word recognition model using spiking neurons based on Maass's Liquid State Machine architecture(LSM; Maass et al., 2002, Neural Computation, 14, 2531–2560). The LSM provides a biologically more realistic account of low-level visual processing than current reading models. The data modelled comes from a study to determine whether type of font (serif vs. sans serif) affected word recognition rates under conditions of varying text visibility. Subjects fixated a central point on a computer display after which a word or non-word was presented randomly on one or other side of this point in either a serif or sans serif font. The subject's task was to decide whether or not the target was a word. Results showed that decision performance was more accurate for targets presented in the right visual field and that sans-serif fonts gave rise to more accurate performance under all experimental conditions. The model successfully reproduced the sans-serif advantage in low-visibility conditions.

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An eye-tracking study of 5th graders watching subtitled television

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Subtitling, a form of text that has a fixed exposure time and is competing for attention in a multimodal environment, is the preferred method of translating audiovisual material in Norway. Research has shown that children benefit from watching subtitled television. Gery d'Ydewalle (1998) showed that Dutch students are able to shift effortlessly between the picture and the subtitles. Similarly, Skovgaard Kristiansen (2008) states that her Norwegian informants claim to read subtitles "automatically", and that they prefer subtitles even if the source language is Norwegian. A pertinent question, however, is how subtitles are read – and how the reading varies. This study explores the reading patterns of 28 Norwegian 5th graders reading subtitles during nine minutes of a subtitled TV-series, relevant to their age and interest.

The preliminary analyses show that 5th graders turn to the subtitles when the subtitles are exposed, read them linearly and return to the picture. They shift their attention to the picture if something interesting happens, and then return to the subtitles where they left off. Preliminary analyses indicate a rationale for choosing one-liner subtitling instead of two-liners when possible, as the poorest readers tend to ignore two-liners to a larger extent than one-liners.

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The effect of capitalization on reading in German

Dennis Nikolas Pauly
University of Potsdam, Germany

German orthography systematically marks nouns by capitalization. Our theory is that the reader benefits by the uppercase-letter receiving syntactic and semantic information, which makes the processing of sentences easier. Former studies didn't deliver satisfactory results, therefore we designed two experiments. In the first participants read four fairy-tales, two in regular German spelling and two in lower case spelling (like English orthography). Highly significant effects were detectable in the total duration of fixations on the targets: durations were substantially longer in the non-capitalized condition. In the second experiment, participants read single sentences with and without capitalized nouns. By using syntactic priming, the sentences are systematically manipulated in order to build up strong expectation of a noun or a non-noun. Our predication when actual syntax was different from primed structure then this will result in increased fixation duration on the target area. This effect will be strong in the non-capitalized condition, and reduced when the noun is capitalized. Results from this experiment are currently be analyzed and will be reported in my presentation.

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Eye-tracking and think-alouds while reading: Threats to internal validity?

Aline Godfroid & Le Anne Lucia Spino
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Eye movement registration in text processing has been hailed as "the closest experimental operationalization of natural reading" (Van Assche et al., 2011, p. 93). Nonetheless, to our knowledge no study has examined the effect of eye-tracking on a study's internal validity; that is, whether eye-tracking affects the reading process. In contrast, an extensive literature has considered the potential reactive effects of concurrent verbal reports on primary task performance (Bowles, 2010; Fox et al., 2011). This study directly compares the reactivity of both methodologies in the context of a second-language reading task.

One hundred and twelve unbalanced Dutch-English bilinguals read English texts containing a total of 12 pseudo-words, which functioned as targets for incidental word learning. Participants were assigned to a silent control (n=53), an eye-tracking group (n=28) or a think-aloud group (n=31). Surprise post-tests in all groups measured vocabulary recognition and text comprehension after reading.

We will compare the eye-tracking and think-aloud groups' post-test scores with those of the control group to establish whether either data collection method was reactive. Our prediction is that the verbal reports but not the eye-tracking are reactive. Results will have implications for researchers who wish to triangulate different methodologies to study online cognitive processing.

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Eye Voice Span in Agglutinative Languages: A Case Study in Turkish

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The distance between eye movements and articulation in oral reading, which is referred to as the eye voice span, has been one of the major research topics in reading research. The previous studies in various languages reveal the influence of two major factors on eye voice span: the frequency of the word in daily use of the language and the length of the word. The frequency information is available through corpus-based statistics in many languages. Studying word length is subject to the limitations introduced by the language under investigation. Agglutinative languages provide an appropriate test environment to study the role of word length on eye voice span, in its relation to morphological word formation processes through the rich inventory of suffixes. Finnish and Turkish are the two agglutinative languages that have also a shallow grapheme-morpheme mapping. In the present study, we report two experiments, in which the participants read aloud sentences that involved target words of different frequency and length. The focus of discussion will be the measures of eye voice span in agglutinative language, such as eye voice span in terms of the number of character spaces, morphemes and words, as well as the time span.

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Posters

Event Detection & Calibration

Tuesday, August 13, 12:00 - 13:30

Room: Athen (ground floor)

Algorithm for detection and quantification of nystagmus

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In many cases, patients suffering from pathological nystagmus are not able to read a newspaper, to drive a car or even to watch television due to oscillopsia. If there would be a kind of optical aid in form of glasses with a video camera, which records the environment and projects the pictures, adjusted with the nystagmus of the patient on the inner surface of the glasses, the patients could have again a stable optical impression. The basis for such an optical aid is an algorithm, which detects nystagmus robustly and distinguishes it from other eye movements, because these should not be compensated. We implemented such an algorithm, which detects individual nystagmus beats and particularly does not misclassify normal eye movements as nystagmus. Additionally, this algorithm is able to detect nystagmus beats in data recorded with different measuring systems and may also be used in clinical routine to automatize the analysis of caloric reflex testing.

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Eye tracking in real world and virtual environments: Algorithms for determining gaze position in 3D space

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Natural gaze behavior takes place in our 3D real world but current remote eye tracking systems are optimized for the measurement on flat computer screens, resulting in 2D gaze information. Here, we explored the calculation of 3D gaze positions based on different binocular eyetracking output parameters. Therefore, real objects were presented in different depth planes within the measuring frustum of a remote eyetracking system while recording eye physiology and gaze data. Algorithms of increasing complexity were implemented for calculating the 3D gaze position to compare deviations of measured gaze from the real object. Results differed between algorithms at hand, with more complex algorithms yielding better performance. In a next step, this experiment has been replicated in a virtual 3D environment. For applications, such as hands free 3D computer operation, real time use of gaze positions is an essential requirement. We discuss our results in terms of the algorithms' complexity-accuracy trade-off.

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Modular pipeline for adaptive 2D feature extraction from eye video

Kristian Lukander, Sharman Jagadeesan & Huageng Chi
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We have developed a novel wearable gaze tracking system, taking a model-based approach to localizing the eye and the gaze vector in 3D. This makes the system considerably robust against slippage of the headgear and requiring only simple user calibration. The 3D model-based approach requires accurate 2D feature extraction from the video stream. Here, we describe an efficient modular pipeline for identifying the tracked features from eye video.

The pipeline processes the eye image in various stages, each implemented as a software component, allowing the modification and optimization of any of the stages independently. The pipeline adapts the thresholding to the lighting level, can make use of a number of feature tracking methods, and ultimately identifies the pupil and enumerates a number of corneal reflections from calibrated IR LEDs.

The pipeline is implemented with C++ and runs comfortably in real-time with a 30Hz USB video stream on a Linux Mint Debian platform running on a standard laptop computer.

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Model-based tracking of a 3D gaze vector from eye video

Sharman Michel Jagadeesan, Kristian Lukander & Huageng Chi
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We have developed a novel, wearable and robust model-based method for tracking gaze from eye video. The gaze vector is defined as the vector passing through the center of the cornea and the center of the pupil, and tracking the gaze requires accurately estimating these positions. Our gaze tracker is a head-mounted frame carrying the eye and scene cameras, the optical system, and the IR LEDs which are used for lighting the eye image, and for generating specular reflections on the corneal sphere. Here, we describe the developed method for localizing the LED position required for estimating the corneal sphere. The location of each LED is calibrated by collecting a number of calibration samples with a first-surface mirror framed by an optical marker pattern. By calculating the orientation and position, i.e. the transformation, of the mirror and localizing the reflection on the mirror, we can calculate "aim vectors" whose intersection defines the position of the LED. The calibrated LED positions, and their respective reflections on the cornea allow us to estimate the center of the cornea in 3D coordinates. The algorithms were tested with OpenGL simulations. Future work includes estimating the cornea radius instead of using a fixed value.

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Posters

Oculomotor Control

Tuesday, August 13, 12:00 - 13:30

Room: Stora salen (2nd floor)

Pre-saccadic attentional shifts depend on saccade execution: Evidence from the stop-signal paradigm

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In the last one hundred milliseconds before the onset of a saccade, perception is facilitated at the saccade target location. This has been attributed to a shift of attention. We examined whether pre-saccadic attention shifts are found even when observers are required to cancel the eye movement. We combined a dual-task with the stop-signal paradigm: Subjects made saccades as quickly as possible to a cued location while discriminating a stimulus either at the saccade target or at the opposite location. To test whether pre-saccadic attention shifts were associated with saccades but not with the mere intention of executing a saccade, a stop signal was presented on a subset of trials at a variable delay (causing observers to successfully inhibit the saccade on 50% of trials). Results show similar perceptual facilitation at the saccade target for saccades with or without stop signal, suggesting that pre-saccadic attention shifts are obligatory for all saccades. However, there was facilitation only when saccades were actually performed, not when observers successfully inhibited them. The tight link between these effects and saccade execution could point to their potential role for the perception of a stable visual world despite saccades provoking continuous shifts of the retinal image.

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Hand drives eyes? Temporal dynamics of saccades during manifold pointing

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Eye movements in rapid pointing tasks have been extensively studied in paradigms where subjects pointed at targets whose locations in space were well-defined. However, little is known about the eye-hand transformation in the absence of prominent target saliency although it is a rather common daily life situation. Here, we recorded saccades during pointing tasks when no salient stimulus was presented (target was a long horizontal bar). In our first experiment we found consistent saccades towards locations along the bar overlapping the final hand positions. Moreover, whilst saccade onsets were delayed in the bar compared to the dot condition, hand movement onsets were found to be target independent. These results suggest that saccade programming during manifold pointing differs from common target-guided pointing. To further investigate the interaction between voluntary eye and hand movements, our second experiment explored the effect of remote distractors with different stimulus onset asynchrony in both bar and dot conditions. An effect on both eye and hand movement dynamics would reveal a sequential command from saccade programming to hand motor plan. In contrast, no effect on either eye or hand movement dynamics would indicate that hand motor plan drives saccade generation in manifold pointing tasks.

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Gain of memory guided saccades is modulated by prefrontal dopamine

Jutta Billino, Jürgen Hennig & Karl Gegenfurtner
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Memory guided saccades require the subject not only to control occulomotor behavior voluntarily, but also to encode and remember the spatial position of a target precisely. Here we were interested in how supposed differences in prefrontal dopaminergic activation in healthy adults affect accuracy and precision of saccades to remembered targets. Catechol-O-methyltransferase (COMT) plays a major role in the regulation of prefrontal dopamine levels. The COMT val158met polymorphism modulates enzyme activity in that met alleles lead to less active dopamine degradation in prefrontal cortex and accordingly to higher dopamine levels. We investigated memory guided saccades in 105 subjects and determined the individual genotypes. While subjects were fixating a target was presented for 200 ms at one of three randomly varied horizontal positions (4, 10, and 16 deg). After a delay of 1500ms the fixation point changed its color and subjects were supposed to saccade to the remembered target position. We found a significant effect of genotype on average gain ($F(1, 105)=4.11$, $p=.045$, $h2=.04$) and a statistical trend for gain variability ($F(1, 105)=3.00$, $p=.086$, $h2=.03$). Met homozygotes ($n=31$) showed lower average gain and higher gain variability than val allele carriers. Our results provide evidence of dopaminergic modulation of saccadic accuracy and precision.

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Priming of attention and saccades by continuity editing and feature repetition in movies

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Professional footage contains cinematic cuts, with either continuity editing or discontinuous editing. The former includes repeating major elements from a pre-cut scene in a post-cut scene. Although cuts constitute abrupt scene changes, they are often not registered by viewers. In two eye tracking experiments we tested the hypothesis that after cuts attention is captured by features repeated from the pre-cut scene. Our participants saw two different sports movies shown silently side by side on one computer screen. Their task was to watch and keep their eyes on one of the movies while ignoring the other. In the task-relevant movie each cut either followed continuity editing rules or not, and occurred at the same time as a cut in the irrelevant movie. Crucially, the movies switched positions at some of the cuts, and participants had to saccade to the current position of the task-relevant movie. Saccadic latency was significantly reduced with continuity cuts as compared to discontinuous cuts. Conversely, results from manual responses indicated that continuity cuts were more often missed when the task-relevant movie continued at the same position after the cut. We will discuss the results with regard to the priming literature and outline further planned experiments.

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Updating the dichotomy of reflexive and voluntary saccadic systems

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Adaptive mechanisms that compensate for the effects of physiological and pathological changes in the oculomotor system are essential for saccadic accuracy. Saccadic adaptation has been studied both in reflexive saccades (RS) and voluntary saccades (VS) via the double step paradigm. The small rate of saccadic adaptation transfer between RS and VS led to the idea that their adaptive mechanisms may rely on different neural pathways. Much research has been done using scanning saccades as a prototype of VS, but less is known about other kinds of VS. We investigated what makes VS "voluntary" by adapting RS and analyzing the transfer rate to VS elicited in various paradigms. After fixation either one (RS) or two stimuli (VS) were presented. In addition to a scanning saccade paradigm, different types of VS were defined by varying the stimuli presentation and the task: sudden or stable target presentation and trialwise or blockwise target instruction. We observed a modulation of the transfer rate from little to almost complete transfer. Our data show that the transfer rate can vary based on how VS are elicited. We suggest an update of the previous dichotomy of reflexive and voluntary saccadic systems into a more continuous frame of reference.

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The neural network of foreknowledge processing in the saccadic system

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Foreknowledge about upcoming events may be exploited to optimize behavioural responses. In a previous work, using an eye movement paradigm, we showed that different types of partial foreknowledge have different effects on saccadic efficiency. In the current study we investigated the neural circuitry involved in processing foreknowledge using functional magnetic resonance imaging (fMRI). 14 subjects performed a mixed antisaccade, prosaccade paradigm with blocks of no foreknowledge, complete foreknowledge or partial foreknowledge about one of stimulus location, response direction, or task. BOLD responses of the fixation periods within each block were compared among the blocks. Complete foreknowledge led to activation of a network including cortical areas such as the prefrontal cortex, anterior cingulate cortex, frontal eye field, posterior parietal cortex, and parahippocampal cortex, as well as increased signal in striate cortex, and subcortical activation in the caudate, putamen and cerebellum. Interestingly, the supplemental motor area was more active in partial than in complete foreknowledge conditions. Response and stimulus foreknowledge led to similar patterns, but surprisingly task foreknowledge did not differ from no foreknowledge. Our results reveal a network involved in foreknowledge, and show different patterns of engagement depending upon precisely what type of information is known.

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Does saccadic adaptation require conscious visual processing?

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Saccadic adaptation is a mechanism that maintains saccade accuracy by correcting systematic errors in targeting saccades. To study the role of conscious perception of the target and targeting error, we examined saccadic adaptation in five hemianopic patients (two with right and three with left homonymous hemianopia), compared to five matched healthy controls. Horizontal 10° saccades were elicited by a target step paradigm toward left or right hemifields in separate sessions. During the adaptation phase, a systematic intrasaccadic backward or forward target step (30% of the first target step) was used to elicit the shortening or lengthening of saccade gains. All healthy controls showed a progressive saccade gain shortening and lengthening, in both hemifields. In patients, a progressive saccade gain shortening and lengthening (expect one patient) were found for ipsilesional targets. A progressive shortening of saccade gain, but no lengthening were observed for contralesional targets. These results suggest that saccadic adaptation may occur if the presaccadic or postsaccadic position of the visual target is in the ipsilesional hemifield. The unconscious processing of the target seems to be sufficient for the analysis of visual feedback on target position, allowing the saccadic system recalibration. These results may have clinical and fundamental implications.

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Are toddlers able to adjust saccade accuracy? Evidence for saccadic adaptation in 24-41 month-olds

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Saccadic adaptation is fundamental to maintaining the accuracy of saccadic eye movements. It adjusts the amplitude of saccades to correct for previous targeting errors, and allows the recovery of accurate targeting behavior in various extraocular and neurological deficits. Saccadic adaptation can be experimentally induced in healthy adults by displacing the target during the saccade: initially, saccades reach the initial target location but progressively, they land closer to the new target position. Here, we examined whether and how these adaptive mechanisms occur in typically-developing toddlers (24-41 months of age). An animated target was presented at different successive locations 10° apart on a screen. While the child was looking toward the target, the target stepped in the direction opposite to the saccade by 2° or 3°. Results revealed that children on average showed a decrease in saccade amplitude over the 120 intrasaccadic target step trials. Importantly, control analyses revealed that this amplitude reduction was not simply due to fatigue or disinterest. However, contrary to an adult group, only about half of the children exhibited a significant adaptation. These preliminary results suggest that the neural mechanisms supporting saccadic adaptation are in place early during development, but may continue to improve through childhood.

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Target location frequency and saccadic reaction time: Evidence for long term effects

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Saccadic reaction times are faster to locations that occur more frequently (Carpenter and Williams, 1995). Within models of saccade latency (such as LATER) this change is accounted for by a modulation in the starting point of the accumulation process. Previous work has shown that such changes in saccadic reaction times could be the result of a temporally local mechanism. Saccadic reaction time to the current target is dependent on the repetition of target location on consecutive trials (Walthew and Gilchrist, 2006).

Here we show that the saccadic reaction time to more frequently occurring locations also changes across testing sessions within a single day and even in some cases across consecutive days of testing. This suggests that there is an additional longer term mechanism driving this effect. We conclude that this apparently simple phenomenon is a product of a number of separate processes acting over very different timescales.

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Dynamics of pre-saccadic attention allocation in the presence of an abrupt onset distractor

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Employing a dual-task paradigm we investigated the dynamics of attention allocation in the presence of an onset distractor prior to saccades (i.e., when movement planning is already in progress). The primary task consisted in making a rapid saccade in direction of a colour singleton, which, on some trials, appeared simultaneously to an onset distractor. The secondary task was to discriminate a small asymmetry in a target cross presented either at the saccade target location, the location of the onset distractor, or in one of two placeholder locations. The perceptual targets could appear at various delays after saccade target presentation. Overall, saccadic responses were faster when the onset was present, but discrimination was less accurate in all locations. Discrimination was best at the saccade target and very poor at the onset, regardless of when it was probed. Performance was also better in trials where the perceptual target was presented at one of the placeholder locations compared to the onset. Apparently, the detrimental perceptual effect of the onset was not a result of attentional resources being drawn to it. We discuss the findings in terms of feature-based attention, enhancing a particular visual representation based on shared colour features, and strategic prioritization.

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Retention of adaptive lengthening of voluntary saccades and effect of manual preference

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The short-term adaptive changes of saccadic eye movement have been considerably studied. In this study, we aimed to evaluate whether the amplitude lengthening adaptation of voluntary saccades can persist over long-term (days or weeks). We also compared rightward and leftward saccades and investigated the effect of subjects' manual preference.

The study was conducted in two groups of healthy volunteers (left-handed/right-handed). During the adaptation session (day D0), each subject performed the pre-test, test and post-test phases. During the test phase, the gain of voluntary saccades (VS) was adaptively increased by using a procedure derived from the double-step target paradigm (McLaughlin 1967). Retention was measured as the saccade gain change at different times after adaptation: immediately (5min after post-test in D0) and over several days (D1, D5, D11 and D19).

Preliminary results over 10 subjects (5left-handed, 5 right-handed) reveal significant increases of saccadic gain relative to baseline (pre-test phase) with a tendency of stronger adaptation for contraversive saccades relative to the dominant hand. Further, a significant adaptation after-effect is revealed until D1and D0 for leftward and rightward saccades, respectively, without significant manual preference effect on retention duration.

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The Global Effect: When Top-down takes over from Bottom-Up

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When elements in a visual scene are positioned in close proximity, eye movements to these elements tend to land at an intermediate location between the elements (i.e. Global Effect (GE)). This effect is most pronounced for short latency saccades and is therefore believed to be reflexive and fully based on bottom-up information. For longer latencies this effect has been known to be modulated by top-down information. In the current study, we established the time course in which top-down information starts to interfere with bottom-up averaging. A standard GE task presented a red and a green stimulus within 20° of each other. When observers were instructed to saccade to the two elements, the eyes landed between the red and green element establishing the GE. However, when observers were instructed saccade to the red element during a block or when the color instruction varied from trial-to-trial, we found an effect of this instruction on the accuracy of the landing position of the saccade. With increasing saccade latencies, the eyes landed closer to the target color. Crucially, however, is that this effect was seen for the shortest saccade latencies ($\sim$ 200 ms), suggesting that saccades are influenced very early by top-down selection processes.

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Localisation errors of multiple objects after eye blinks and saccades

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Localisation studies indicate that systematic spatial compression occurs when holding a representation of object locations in working memory. Spatial compression also occurs when making a saccade immediately after stimulus presentation. The effect of eye blinks (possibly similar to saccades) has not been examined in this context.

To understand the source of localisation errors, the current study compares the effects of saccades and blinks when reproducing the locations of 1–5 randomly-placed discs presented immediately prior to a saccade or blink; these results are compared to a control condition where observers simply hold the representation in working memory for the same duration. This experiment allows us to further explore the role of visual working memory in the perceptual phenomena related to saccadic compression, as memory must be used to maintain information across saccades. It will also establish the effect of blinking on localisation.

The preliminary findings show that overall localisation errors are higher in saccade trials than in blink and control trials. Further analysis of the data will establish the time course of mislocalisation errors relative to saccade and blink onset. This will allow us to uncover the interaction between working memory and eye-movement effects on peri-saccadic localisation of visual stimuli.

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Remote distractor effects in a go/no-go task: differences between foveal and peripheral distractors

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Saccades are delayed when a remote distractor is presented along with the saccade target. Previously, we observed that the delay was longer for distractors sharing the target's color. This color similarity effect increased across time with central, but not with peripheral distractors. Here, we compared effects of central and peripheral distractors in a go/no-go task: Observers made saccades towards targets of a predefined go color and withheld the response for no-go color targets. Distractors were presented in the go, the no-go or a neutral color at a response-irrelevant location. We expect go-colored distractors to delay responses because of their similarity to the target. At the same time, we also expect no-go color distractors to delay responses because their color is associated to withholding the response. To analyze effects across time, targets and distractors were presented with different stimulus onset asynchronies (SOAs). For central distractors, go color distractors delayed responses more than no-go or neutral color distractors. There were no modulations across SOA. For peripheral distractors, go-color distractors delayed responses more when the distractor was presented late, but less with early distractor presentation. Our findings confirm that central and peripheral distractor signals are differentially modulated by top-down mechanisms across time.

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Influences of the vertical meridian on the global effect

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The global effect is often attributed to averaging of target and distractor related activity in a spatial map, such as that in the superior colliculus. However, the superior colliculus encodes almost solely the contralateral field. Hence we ask if the global effect is diminished or absent if target and distractor are on opposite sides of the vertical meridian.

12 subjects made oblique saccades to targets at 8° eccentricity and 15° in polar angle from either the horizontal or vertical meridian. Distractors, if present differed from target direction by 30° of polar angle, with the same eccentricity, either right or left of target. We assessed the directional angle of saccade endpoints.

We found that all distractors generated global effects. The magnitude of the global effect did not differ between distractors on the same or opposite side of a meridian, regardless of whether this was the horizontal or the vertical meridian.

We conclude that global effects are not diminished when the target and distractor occupy opposite vertical hemifields. This suggests that either the colliculus has mechanisms for integrating information from the opposite tectal map, or else receives averaging input from upstream ocular motor structures, such as the frontal or parietal eye fields.

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Violating the main sequence: Asymmetries in saccadic peak velocities for saccades into the temporal versus nasal hemifields

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There is a tight relationship between saccadic amplitude and peak velocity (PV). This 'main sequence' relation is approximately linear for saccades of amplitudes up to about 20° (Bahill et al. 1975). Here, we present evidence for deviations from this. We tested performance characteristics for saccades into the nasal versus temporal hemifields under monocular presentation. While little differences in latency were observed, saccades into the temporal hemifield had considerably higher PVs than saccades into the nasal hemifield. This difference was not accounted for by differences in amplitude between the hemifields in contrast to expectations from the main sequence. Under binocular viewing there was a slight NTA in PV. These asymmetries were most pronounced for the lowest amplitudes (5° to 8°) and decreased with higher amplitudes. The observed NTAs in PVs are in good accordance with other NTAs in visual performance (saccadic choice [Posner and Cohen 1980], attentional effects [Rafal et al. 1989], responses to face-like stimuli [Tomalski et al. 2009]) and anatomical NTAs found in retinal ganglion cell density (Curcio and Allen 1990) and in the optic nerve (Williams et al. 1995). Whether the anatomical NTAs account for the NTA observed for peak velocities is not known; further research is needed.

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Control of saccadic eye movements: Impact of stimulus type on effects of flanker, flanker position and trial sequence

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The experiment demonstrates the impact of stimulus type on the control of saccadic eye movements. More specifically, using the flanker paradigm, we examined whether stimulus type (arrows vs. letters) modulates effects of flanker and flanker position. Further, we assessed trial sequence effects and whether they are affected by stimulus type. A central target (a '<' or '>' in the arrow condition or an 'N' or 'X' in the letter condition) instructed a left- or rightward saccade. The target was accompanied by a congruent or incongruent flanker, shown to the left or right of the target. Considering the different processing required for arrows and letters, dissimilar flanker effects (FE), flanker position effects and trial sequence effects were predicted for arrows versus letters. The main findings demonstrated that (i) flanker effects were stronger for arrows than letters, (ii) flanker position more strongly modulated the flanker effect for letters than arrows, and (iii) trial sequence effects partly differed between the two stimulus types. We discuss these findings in the context of a more automatic and effortless processing of arrows, being overlearned symbols of direction, relative to letter stimuli.

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Top-down and bottom-up control of oculomotor responses in dual tasks

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For a long time, empirical research suggested that oculomotor control is largely unaffected by additional response demands in other effector modalities. However, recent research suggested that although saccade control generally appears to be prioritized among other simultaneously executed response modalities (e.g., manual or vocal responses), oculomotor performance decrements can still remain substantial. In the present study, we examined the timeline of oculomotor performance decrements in multitasking situations by systematically manipulating the inter-stimulus interval between an oculomotor and a manual reaction task (psychological refractory period or PRP paradigm). While Experiment 1 involved a variable stimulus order, in Experiment 2 the stimulus for the manual response was always presented prior to the stimulus for the saccade. Results indicated that saccade performance strongly suffers from the additional execution of a manual response in close temporal proximity (PRP effect). Furthermore, an analysis of response order revealed that variable stimulus order in Experiment 1 triggered a strategic prioritization of saccades over manual responses when compared to the fixed stimulus order in Experiment 2. The results are interpreted in terms of an interaction of bottom-up and top-down control of oculomotor responses in dual-task situations.

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Do luminance and orientation influence saccade metrics irrespective of the difficulty of the saccade-target task?

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Luminance and orientation are known to influence where the eyes move in visual displays. It still remains undetermined whether both intervene in a bottom-up, automatic manner, and whether their effect is reinforced when the location of the saccade target is uncertain and visual-discrimination processes are involved. Here, we tested the effect of luminance and orientation on saccade metrics in a two-stimulus visual display, for two conditions of target-location uncertainty, i.e. minimal (the target was always more eccentric than the distractor) vs. maximal (the target was more or less eccentric than the distractor). The target was a vertically-elongated area, which differed from the textured background (an array of tilted Gabor patches) by its luminance; the vertically-spread distractor differed by its luminance, orientation or both. Results showed that in minimal-target-uncertainty conditions, luminance-defined distractors deviated the eyes from the target (compared to a condition with no distractor), while orientation-defined distractors had minor effects. Importantly, both distractors induced greater deviations under maximal uncertainty, though luminance-defined distractors still produced greater and qualitatively-different effects. Thus, although luminance seems more prone to generate automatic effects than orientation, both features influence saccade metrics differently depending on the level of visual processing involved and their relevance for the task.

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The neural substrate of saccade generation under different levels of cognitive control

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Using fMRI, we investigated the neural substrate of saccade generation in four conditions requiring different levels of cognitive control. In Condition 1, participants generated a saccade to a single target, which requires only a simple mapping between the stimuli and response. In Condition 2, two stimuli were present, one high and one low contrast. Participants were instructed to saccade to the brighter stimulus, this introduces selection to the task. In Condition 3, the displays were identical to Condition 2, but now participants were instructed to saccade to the low contrast stimuli, introducing a need to inhibit the non-target stimuli. Condition 4 used the same displays but participants were instructed to freely choose a target on each trial. We used saccade contingent displays to exactly match visual stimulation across conditions and used a continuous saccade paradigm which eliminated the need for return saccades. Changes in the level of cognitive control were associated with: differential levels of activity within the saccade circuit; the recruitment of additional brain areas and task-dependent changes in functional connectivity. We find similarities, but also differences, between our results and anti-saccade fMRI studies.

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The effects of monetary reward on prosaccades and antisaccades

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Extensive research has demonstrated how rewards can influence the programming and function of saccades in non-human primates. However, little is known about the effects of rewards on the function of eye movements in healthy human participants. Here, the effects of instrumental conditioning of eye movements were investigated in human participants. Specifically, participants were given a small financial reward for making one particular eye movement. The reward modulated saccade metrics, such that latencies to a rewarded location were shorter than those to unrewarded locations and there were more erroneous saccades towards the rewarded location. This bias persisted throughout the extinction period. A further experiment, demonstrated that instrumental conditioning of prosaccades had no effect on the metrics of antisaccades. Small monetary rewards were able to successfully induce a sustained bias in the oculomotor system this is specific to stimulus driven eye-movements.

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Transfer of saccadic adaptation to covert attention

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Visual exploration involves tightly inter-related ocular saccades and covert shifts of visuo-spatial attention. The saccadic system continuously adapts to perturbations, but it is unknown whether such saccadic adaptation transfers to covert attention deployed in peripheral visual detection tasks.

Healthy participants (N=40) separately performed one of four exposure phases: adaptive shortening of leftward or rightward reactive saccades ("adapt-left"/"adapt-right", double-step target paradigm of McLaughlin 1967) or mere execution of leftward or rightward saccades ("control-left"/"control-right", single-step target paradigm). Covert attention was tested before and immediately after each exposure phase in a visual detection task where subjects, while continuously maintaining central fixation, pressed a button as soon as an exogeneous visual cue flashed in the left or right hemi-field.

As expected, the gain of saccades toward the adapted hemi-field decreased significantly in both "adapt" groups (-15% on average), while saccades to the non-adapted hemi-field remained unchanged. Interestingly, cue detection reaction times decreased significantly in the "adapt-left" group for left-sided targets only (mean change= -7.5%), regardless of target eccentricity. No change in detection performance was observed in either control group nor, surprisingly, in the "adapt-right" group.

Current experiments test whether this hitherto unreported hemi-field specific coupling between adaptation and covert attention extends to voluntary saccades.

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Action Effects in Saccade Control

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According to the ideo-motor principle, action preparation involves the activation of associations between actions and their anticipated effects. However, there is only sparse research on the role of anticipated action effects in saccade control. In our study, participants responded to lateralized auditory stimuli with spatially compatible saccades towards peripheral targets (e.g., a rhombus in the left hemifield and a square in the right hemifield). Prior to the imperative auditory stimulus (e.g., a left tone), an irrelevant central visual stimulus was presented which was either congruent (e.g., a rhombus), incongruent (e.g., a square), or unrelated (e.g., a circle) to the peripheral saccade target (i.e., the visual effect of the saccade). Saccade targets were present throughout a trial (Experiment 1) or appeared after saccade initiation using gaze-contingent display change procedures (Experiment 2). Results showed faster RTs and fewer errors in congruent (vs. incongruent) conditions, suggesting that associations between oculomotor actions and their visual effects play an important role in saccade control.

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Does the Superior Colliculus play a role in human Optokinetic Nystagmus?

James John Harrison, Tom Freeman & Petroc Sumner
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Optokinetic nystagmus (OKN) is a gaze-stabilizing eye-movement consisting of slow, tracking phases alternating with fast, resetting jumps. Despite the saccade-like appearance of the resetting fast-phases of OKN, they are not thought to involve one of the main control centers for saccades, namely the superior colliculus. However we have shown that OKN fast-phases affect, and are affected by phenomena strongly associated with activity within the superior colliculus. Firstly, the fast-phases of OKN are delayed by the onset of irrelevant distractors in just the same way as saccades (the 'saccadic inhibition' effect) and secondly; horizontal OKN causes curvature in concomitantly executed vertical saccades. This implies that activity in the superior colliculus affects the onset of OKN fast-phases, and that OKN fast-phases can act like competitive saccades to cause curvature. We therefore argue that the superior colliculus should be considered part of the OKN network, and build upon previous work which suggests there is no sharp dichotomy between reflexive and voluntary movements.

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Gap effect by gradual brightness reduction

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The saccadic reaction time (SRT) is defined as the interval between the onset of an appearing eccentric target E to the start of the saccade to E, when the eye is fixating at a stimulus F, that is offset at the same time E is onset. The gap effect (GE) refers to a SRT reduction when F is offset some time (gap) before the onset of E. The overlap condition (OC) refers to a SRT increase when F is not offset and remains after the onset of E. The SRT is influenced by manipulating the visual stimuli, such as changing their size or luminosity. In this paper we investigate a novel visual manipulation of F named gradient gap effect (GGE). In the GGE, the brightness of F is gradually reduced before the onset of E. Experimental results with 8 participants using several gap values show that there is no significant difference between the GGE and GE, suggesting that gradually reducing the brightness of F before the onset of E also produces a gap effect. The gradual reduction is more appropriate as a visual feedback mechanism, and can be exploited to facilitate gaze interaction with computers.

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Are saccadic decision mechanisms distinct from or similar to other modalities?

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Many papers on selection/decision promote saccades as a model system, but are saccades in fact special? The reported absence of a manual remote distractor effect (RDE) implies fundamental differences, since the RDE is critical evidence for competition by mutual inhibition. Here we compare saccades and manual button-presses (the response mode used in most psychology and cognitive neuroscience) for two related phenomena: the RDE and 'saccadic inhibition' (distractor-induced dips in latency distribution). Taking a modelling approach, we conclude that despite superficial differences, the decision processes may be similar. Interestingly, the extra delay and variance in manual vs saccadic responses is best accounted for by non-decisional delays, not a difference in the decision process itself. Further, we tested whether three different types of model can account for the shapes of both saccadic and manual latency distributions across all distractor conditions. Although a mutually-inhibiting version of LATER/LBA (called ALIGATER) accounts for manual but not saccadic behaviour and the classic diffusion model accounts for saccadic but not manual behaviour, the third model (DINASAUR, based on non-linear input dynamics) can account for both saccadic and manual response distributions by simply adjusting the balance of fast transient and slow sustained input.

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Posters

Static & Dynamic Scene Perception

Tuesday, August 13, 12:00 - 13:30

Room: Stora salen (2nd floor)

Eye movements in natural movies under spatio-temporal blur

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We investigated how global changes to the distribution of saliency in dynamic natural scenes affect eye movement characteristics. To this end, we modified the spatio-temporal amplitude spectra of HDTV video clips (1280x720 pixels, 30 fps, 8 s duration) of indoor and outdoor scenes from the VAGBA dataset by filtering them on an anisotropic Gaussian pyramid with five spatial and four temporal levels.

Eighteen subjects watched 50 such videos where each video was filtered using one of ten different filter bandwidths (corresponding to individual levels of the pyramid) that were balanced across movies and subjects. Eye movements were recorded binocularly at 1000 Hz with an EyeLink 1000 eye tracker; overall, more than 12000 saccades were collected.

An analysis of basic eye movement characteristics revealed that blur affected both saccade amplitudes and fixation durations, and that spatial and temporal blur had different effects. Largest amplitudes and shortest fixation durations were observed under 'no blur' conditions. Surprisingly, spatial blur decreased saccade amplitudes more strongly than temporal blur. A further analysis of inter-subject gaze variability (Normalized Scanpath Saliency) showed that gaze patterns became more similar with blur.

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Gaze contingent luminance shifts show evidence for asymmetrical control of fixation durations in scene viewing

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In two experiments we investigated the control of fixation durations in naturalistic scene viewing. Evidence from the scene onset delay paradigm and numerical simulations of such data with the CRISP model (Nuthmann, Smith, Engbert, & Henderson, 2010) has suggested that processing related difficulties may result in prolonged fixation durations. Here, we ask whether processing related facilitation may lead to comparable decreases to fixation durations. Research in reading (Kennison & Clifton, 1995) and visual search (Hooge, Vlaskamp, & Over, 2007) has reported only uni-directional shifts. To address the question of uni-directional (slow down) as opposed to bi-directional (slow down and speed up) adjustment of fixation durations in the context of scene viewing we compared the effect of gaze contingent luminance shifts during saccadic eye-movements on fixation durations. Results demonstrate that degrading the stimulus by shifting luminance down resulted in an immediate increase to fixation durations. Furthermore, clarifying the stimulus by shifting luminance upwards also resulted in an immediate increase to fixation durations. The magnitude of this increase was less in the UP condition than in the DOWN condition. These results suggest that the control of fixation durations in scene viewing is asymmetric, as has been reported for reading and visual search.

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The left and right in paintings

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Does orientation play a role in how people look at artistic paintings? From a hermeneutic perspective, renowned Swiss art critic Heinrich Wölfflin postulated that the impression of a mirrored version of a painting should be severely distorted, because people tend to look at pictures from left to right, consistent with a culturally acquired reading direction bias. Few empirical studies have addressed this hypothesis, and provided little supporting evidence (e.g., Hooge & van de Grind, ECVP 2010). Here we studied Wölfflin's hypothesis by presenting different groups of participants with the original or a mirrored version of paintings (taken mostly from Wölfflin, 1928) while measuring their eye movements. Half of the participants in each group started from left or right. AOIs were determined by convex hulls around k-means clusters. Results suggest that whereas there is a clear dominance of salient objects in determining the order of fixations, mirroring also has a substantial effect. For example, in Katsushika Hokusai's famous woodblock print "The great wave off Kanagawa", attention is drawn to Mount Fuji earlier in the mirrored version, when the wave does not block the path towards it. Artists seem to know how to guide viewers' attention, and use knowledge about cultural biases.

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Mechanisms of scene perception at different ages: The development of eye-movement control

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Recently, two distinct attentional modes, ambient and focal, have been associated with specific eye movement patterns. Ambient processing is expressed by short fixations and large saccade amplitudes while the focal mode is indicated by longer fixations embedded in short saccades. The ambient mode serves localization of objects and dominates early scene viewing. Focal processing is associated the identification of object details and appears later during scene exploration. So far, studies have only focused on adults and only little is known about the development of these mechanisms. Studies in children have revealed that ocular-motor behavior continue to mature up to adolescence. In our study, subjects of four different age groups (2, 4-6, 6-8, 8-10 years) and adults inspected images while eye-movements were measured. Longest fixation durations and shortest saccade amplitudes were found in the two youngest age groups, suggesting that the eye-movement control is developing until the age of six. Comparing early and late phases of scene viewing revealed no difference in fixation durations, but longer saccade amplitudes during the early phase in all groups. The results support, at least partly, the division of ambient and focal processing strategies starting as early as two years of age.

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Context influence on multiple object recognition

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The human visual system can rapidly recognize natural objects in natural scenes. There are some peculiarities that distinguish human vision from machine vision: more rapid recognition of objects in scenes than when they are presented individually; objects are recognized by the methods of simultaneous and successive analyses. The aim of our research is to define conditions and image features that influence the recognition of several objects presented. Influence of context and the nature of objects (natural, artificial, or ambiguous objects) on recognition dynamics of objects is being investigated in psychophysical experiments. In these experiments the stimuli are presented at a very short period (100 ms). In order to catch attention shifts we are performing another series of experiments with eye movement registration. A visual stimuli with three objects of different or same categories are presented for 1 sec. We register eye movements by Eyelink 1000 eye tracker. Our aim is to find relation between gaze fixation duration on a particular object and previously fixated object whether it was of the same or different category. Analysis of errors in object recognition allows us to determine how much contextual information facilitates recognition. Individual differences also are being analyzed.

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Gender Differences in Perceiving Documentary Videos

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This research investigates the relationship between the gender of the viewer exposed to a certain documentary video and the gender of the subjects shown in the video.

The objective was to find out whether:

1. there is a preference towards subjects of the same gender as a way of identification with the role they are presented with; 2. heterosexual viewers are more interested in examining subjects from the opposite sex; 3. viewers will spend more time observing the more attractive subject independent from their gender;

The stimuli used during the eye-tracking study consist of documentary footage from four different weddings in which there are clear gender roles, sexually appealing subjects, and cultural convention that the bride is "the most important one". This is a work in progress, however, the preliminary results showed that both men and women spent more time looking at the bride than at the groom ($p<0.001$). Analyzing gaze time only on the faces, the similar result is found: bride's face attracts more attention ($p<0.001$) from viewers of both genders.

However, men were more interested than women in looking at the groom's face, while women (compared to men) looked longer at the bride's face.

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Color distance on choropleth maps: an eye-tracking study on geospatial information legibility

Alžběta Brychtová & Stanislav Popelka
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In cartography color is one of the most important carriers of the geospatial information. Among other visual variables, color plays a dominant role in legibility problems of maps. Color distance allows to quantify the ability to recognize difference between two colors. To evaluate influence of color distance on map legibility an eye-tracking study was performed.

Experimental stimuli were arranged so that they cover different values of the color distances between elements on a map in order to determine the threshold of map user ability to differentiate depicted information. Experiment participants were asked to estimate the value of region in choropleth map using a map legend. Several metrics derived from eye-tracking data of 40 participants were analysed – fixation count, average duration of fixations, scanpath length and time to find the right answer on the question. The main goal of the study was to reveal patterns in using map legend to find out the information. For this purpose scanpath comparison was applied. For the experiment purposes the SMI RED 250 with appropriate software was used. Data analysis was performed in Ogama, R , eyePatterns and Common GIS.

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User study for representing the spatial data uncertainty with use of cartographic symbols

Jan Brus & Stanislav Popelka
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This paper presents a study focused on spatial data uncertainty visualization. The whole experiment is framed from typology and techniques for visualisation of different categories of spatial data quality presented as uncertainty visualisation. We present a user study that evaluates the perception of uncertainty visualisation presented by cartographical symbols based on most commonly used techniques for displaying uncertainty in spatial data and cartographical principles. The study uses data that were designed to represent the uncertainty connected with space, time and attribute components. Experiment was focused on intuitiveness of several visualisation techniques and also based on user preferences. Several cartographical symbols were presented with aim to find user strategy in reading this kind of spatial information. Performance within the context of the usability assessment in this research was measured by eye-tracking metrics. . The user preference was based on the visual appeal and comprehensibility of the methods. Measurement of correspondence between their performance and preferences were analysed. Finally the most suitable uncertainty visualisation method(s) were derived and experiments results should help the users to determine the uncertainty visualisation method(s) that are most suitable according to their domain of expertise.

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Does colour matter in comics' reading?

David-Alexandre Wagner & Per Henning Uppstad
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Although comics are a cultural object that has been expanding its sphere of influence among leisure products in most western societies over the last decades, few studies have addressed comics in a perspective using cognitive measurements and quantitative methods. Since the alleged invention of comics in 1827, there has been a vivid tradition of publishing comics in black and white, which continues nowadays alongside many albums in colour. At first sight, this surface feature is one of the most striking differences between different albums. And yet, the role of colour in natural scene detection and recognition remains disputed and quite unresolved. The purpose of this paper is to evaluate the impact of colour in comics' reading by studying eye-movements' of 18 adult participants (7 males, ages 19-33, mean 23) reading two different extracts from the same comics album, either in colour or in black and white, using a SMI tower-mounted high speed eye-tracker. The first general results show tendencies of longer and fewer fixations when reading extracts in colour but seemingly no significant differences. But since comics combine text and picture, the exploitation of the data needs to be refined, isolating also scene recognition in itself. This work is in progress...

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Using Eyetracking to Measure Intercultural Competence

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A major challenge in intercultural competence trainings is to foster the ability that people are able to bring more than one perceptual and conceptual discriminations to bear on a cultural event. This establishes complexity and richer experience. In order to measure intercultural competence and its advancement in subjects, we combined eyetracking stimuli and questionnaires. According to the developmental model of intercultural sensitivity (DMIS) by Bennett, intercultural competence moves from ethnocentric to ethnorelative stages. If the DMIS is a development model of cognitive structure, we should be able to document noticeable changes in attention strategies with which we can additionally measure the level of intercultural competence of subjects in an experimental eyetracking paradigm.

As expected, the eye gaze protocols of the tested subjects (n=20, Eyelink 1000) differed significantly and we prototyped three discernable gaze patterns, which we referred to as: the culturalized ethnocentric gaze (CECG), the culturalized ethnorelative gaze (CERG) and the intercultural gaze (ICG). The scanpaths differed in gaze duration and cumulative viewing time on preference decision AIs as well as saccades to and from culturally relevant, disambiguating items. Hence with the help of eyetracking data we were able to visualize three stages of intercultural competence in our subjects.

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Posters

Social Gaze & Joint Attention

Tuesday, August 13, 12:00 - 13:30

Room: Stora salen (2nd floor)

Gaze cueing and social roles in a real-world collaboration

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During collaboration, people communicate using verbal and non-verbal cues, including gaze cues. There is evidence that social factors affect gaze allocation, however most research on gaze cueing has not considered these factors. The present study manipulates the presence of social roles in a collaborative task, whilst measuring the eye movements of participants. In pairs, participants worked together to make the batter for a cake. Half of the pairs were given roles ("Chef" or "Gatherer") and the other half were not. Across all participants we found, contrary to the results of static image experiments, that participants spent very little time looking at each other, challenging the generalisability of the conclusions from lab-based paradigms. When given spoken instructions, listeners in the roles condition looked at the speaker significantly more than listeners in the no roles condition. We conclude that our tendency to seek the gaze cues of collaborators is affected either by our social perceptions of the collaborator or their perceived reliability.

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Social attention in real world scenes: Gaze following is modulated by the visibility of the target

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Previous research has shown that people automatically attend to locations looked at by others, a process known as gaze following. Moreover, when viewing images of scenes containing people, participants tend to prioritize faces and objects that are looked at. The aim of this study was to investigate whether overt gaze following is modulated by the person's mental state, namely by what the person can see. We monitored participants' eye movements whilst they freely viewed real world scenes containing a person either looking towards or away from an objet. We also manipulated whether the looked at object was in full view, or blocked by a natural barrier (e.g. a box placed in the line of sight). Our results showed that people generally prioritize face. Moreover, looked at objects were fixated significantly more rapidly, and longer, than objects that were not looked at, thus demonstrating that gaze cues influence where we look. However, crucially these effects were modulated by whether the persons' view was obstructed or not. Our results demonstrate that social cues strongly influence where people look, and that that this gaze following is influence by the mental state of "seeing and object".

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Sound changes attentional synchrony in a dynamic social stimulus

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Measuring eye gaze in complex, dynamic and social stimuli has the potential to reveal much about human social attention. Previous research demonstrated that observers watching a conversation tend to look at the eyes of conversants, and that they were sensitive to the timing of speech. In a new experiment, participants viewed video clips of four people involved in a discussion. By removing the sound from some clips, we asked whether auditory information would affect when speakers were fixated and how fixations between different observers were synchronised. The results showed that sound changed the timing of looks—by attracting attention to the speaker. Clips with sound also led to greater attentional synchrony, with more observers tending to fixate the same regions at the same time, and to a change in the degree to which the eyes and mouth of the actors were fixated. These findings provide an example of multimodal social attention in a naturalistic stimulus.

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Are the lover's faces processed as quickly as self-faces?

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Many studies have found that adults manifest self-face advantage. Compared to the unfamiliar faces, people responds faster to self faces in visual search or face orientation identification task. What about the lover's faces? In the present study, two experiments were conducted to test if observers process their own face as quickly as they process their lover's faces. The eye tracker and the visual search task were used in the experiments. In experiment 1, participants were asked to find a target face (self, lover, or unfamiliar face). It took shorter time for the participants to find out self and lover's face than unfamiliar faces, there was no significant difference between the self and lover's face. In experiment 2,to examine if self and lover face advantage appeared in a visual search task in which the face identity was task-irrelevant,participants were asked to find a target mouth from different faces. The result showed that the participants find out the target mouth displayed by self and lover' face faster than by the unfamiliar face. Therefore, our results showed that people process their own faces as quickly as they process their lover's faces. It might suggest that individuals also have the lover-face advantage.

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What the eyes tell about joint attention

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Human primates use a plethora of visual cues to allocate attention. Some of these cues are social in nature, like perceived gaze direction of another person. The process through which an observer allocates his/her attention based on the attention of another person is known as joint attention. To be able to do this, the observer effectively has to compute where the other person is looking. We report on experiments in which participants are presented with a computer-generated person looking at one of a series of possible objects. The participant's task consists of making an eye movement to where the stimulus figure is looking. We manipulate head (and eye) and body orientation of the stimulus figure and measure eye position. We document that both head and body orientation play a role in determining where another person is attending and that there are systematic interaction effects between different body parts.

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Gaze of a face fixation stimulus influences the saccadic gap effect

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A removal or change of a fixation stimulus prior to presentation of a peripheral target shortens saccadic latency (saccadic gap effect). We investigated how social signal from a fixation stimulus would interact with the saccadic gap effect. A trial began with presentation of a cartoon face, which served as a fixation stimulus, having direct (or averted) gaze. Then the pupils were kept unchanged, disappeared, or translated vertically making averted (or direct) gaze. After a 200-ms delay period, a peripheral target appeared on the left or right of the fixation stimulus. Observers required making a saccade towards the target as quickly as possible. The results showed that the saccadic latency was shorter when the pupils disappeared than when they kept unchanged regardless of the initial gaze direction, replicating the gap effect. Furthermore, while the change from directed to averted gaze shortened the saccadic latency, the change from averted to directed gaze eliminated the facilitation. These results suggest that the saccadic gap effect can be modulated by social signal from the fixation—the emergence of direct gaze interferes with the facilitation of subsequent saccade caused by a physical change of a fixation point.

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Lie-Tracking: Investigating Gaze when Detecting Deception

Jonathan P. Batten, Gordon R. T. Wright, Rebecca Nako & Tim J. Smith
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Discerning a lie from a truth is believed to be aided by sensitivity to subtle 'leakage' cues, revealing the 'true' emotion behind that displayed. The aim of this study was to investigate gaze behaviour as a function of accurate deception detection and truth-bias. 80 videos conveying truthful and deceptive opinions were presented to 31 participants who rated them as truth or lie while their eye movements were recorded. No significant variation in dwell time across the eyes, nose and mouth was observed as a function of accuracy, measured using d-prime. Variation in dwell time in the left eye, independent of other face regions, showed a trend towards significance between those with high and low truth-biased responses. Pupil dilation as a measure of cognitive effort significantly varied as a function of task difficulty, but not as a function of accuracy. The accuracy findings reinforce the existing 'deception cues' literature, detailing large individual variability that undermines any defined predictive gaze behaviour. The role of the left eye in truth-bias responses is discussed with reference to lateralisation and deception cue evidence.

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Top-down Modulation of the Oculomotor System: the Effects of Status and Culture on Social Perception

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Social status determines how societies are structured and individuals interact. It influences how we look at people's faces and respond to their gaze. Yet, the way status is construed differs between cultures. Here we hypothesize that differences in how status is achieved will be manifest in gaze patterns. We compared French culture, where social class is considered to be the primary basis of status, with American and British cultures, where individual merit is considered to be the primary basis of status.

In study 1, we examined cultural differences in eye movements when watching videos of community members talking about topics unrelated to identity. French participants looked more to upper class compared to lower class targets' eyes. This was not the case for American and British participants. In study 2, we manipulated two status dimensions, social class and competence, using priming. Consistent with study 1, gazes of French participants depended more on targets' class affiliation. In contrast, gazes of American participants were more influenced by targets' competence level.

Our results suggest that gaze is top-down modulated by cultural definitions of status. We draw upon comparative psychology and social neuroscience to provide insight into social and perceptual functions of gaze across cultures.

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Social Learning from Modeling Examples: Effects of Seeing the Model's Face

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In video "modeling examples", another person (the model) shows students how to perform a task. Such examples can either show the model entirely, partly, or not at all (screen recordings). This study investigated whether seeing the model's head in the video would hinder learning. This could be the case because people tend to look primarily at another person's face when hearing someone relate an event; for learning, however, the focus should be on what the model is demonstrating. On the other hand, in learning situations, the attention focus might already be directed more towards the task being demonstrated. In this experiment, 43 participants twice studied a video modeling example in which a problem-solving task was demonstrated and in which the model's face was either visible or not and subsequently attempted to solve the problem themselves. Results showed no performance differences on the first attempt, but a marginally significant advantage for the condition that did see the model's head on the second attempt (i.e., after the second example had been studied). Preliminary analyses of the eye movement data for this condition showed a decrease of the number of fixations on the model's head during the second observation of the example.

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What's in a representation? Intention to act influences on-line perception, but not off-line retention

Clare Kirtley & Benjamin Tatler
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Given that one role of vision is to collect information that is required for upcoming tasks, it may be that scene representations are formed so that, in the context of action or intention to act, they show a bias to task relevant features with important features held more stably in memory.

In the current study, the participants' intentions towards scenes were manipulated by the performance of different grasping postures as they observed the scene. Measures of eye movements and memory for item properties in the scene were taken, to determine if the posture affected how scenes and objects were examined and subsequently remembered. The eye movements of participants were influenced by their intention group such that conditions in which a power grasp was formed led to significantly longer fixation durations on power objects. In contrast, memory for these objects and their properties were not benefitted by the intentions.

While previous studies have shown that intention tasks can affect the on-line perception of objects, the current study suggests that this may not extend to the off-line representations. Potential factors such as task specificity are discussed in reference to these results and the formation of representations for action in general.

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Eyetracking reveals a difference in Facebook viewing strategy based on motivation

Graham G. Scott & Christopher J. Hand
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For many individuals, social networking has become an important part of everyday life. The most popular social network, Facebook, currently has over one billion users. Although individual profile components (e.g., number and attractiveness of friends) are known to affect viewers' perceptions of profile owners, no empirical study has investigated the visual processing of such profiles. The current experiment had participants view four timelines (two male, two female), two as potential 'friends' and two as potential 'employees'. Analyses revealed distinct viewing strategies dependent on appraisal category and effects of timeline owner gender on eye movement behaviour. Both banner picture and personal information (including number of friends and photographs) were fixated less often when the target was being appraised as a potential employee. Recent wall posts were viewed earlier when the target was male and a potential employee. This demonstrates for the first time that viewers alter their processing strategies of social networking profiles based on motivation (judging a potential friend vs. a potential employee). The importance of this finding is that because the different elements of profiles are viewed earlier and/or for longer – depending on viewer motivation – the weight of these elements in impression formation may vary.

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Working memory influences the time-course of perspective taking in the Keysar task: an eye-movement study

James Cane[1], Heather Jane Ferguson[1] & Ian Apperly[2]
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Recent research has demonstrated a link between perspective-taking and executive functions. Here we examined the effect of working memory load on online perspective-taking ability using a 'Keysar task'.

Participants moved target objects around a grid based on instructions from an avatar. In a 'listener privileged' condition, an alternative target object was only available to the participant. In a 'speaker privileged' condition, one grid square was covered to the participant, indicating a potential target only available to the speaker. In a control condition, objects were available to both participant and speaker. Working memory load was manipulated within each condition. A further experiment examined whether increasing participants' motivation to use perspective modulates WM effects.

Analyses revealed that listeners were less likely to fixate on targets when they held privileged knowledge of an alternative target object. Listeners' fixations were not influenced by the speaker's potential knowledge about an alternative target. However, high working memory load decreased fixations on target objects in both the listener and speaker privileged conditions.

These results show that holding privileged knowledge about events interferes with our ability to take another's perspective. This ability being further impaired by loading working memory demonstrates that successful perspective-taking is cognitively effortful.

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Posters

Attention

Wednesday, August 14, 12:00 - 13:30

Room: Stora salen (2nd floor)

No evidence for attentional momentum: four studies with and without eye movements

Jonathan Harris, Raymond M. Klein & David A. Westwood
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Responses are slower for visual targets appearing in the same location as a prior (300+ ms) cue. Posner and Cohen (1984) considered and rejected the possibility that this phenomenon is due to a sort of 'attentional momentum' (AM), favoring instead an inhibitory tagging mechanism that discourages the return of attention, 'inhibition of return' (IOR). Recent studies provide evidence both for (e.g., Pratt, Spalek & Bradshaw, 1999) and against (e.g., Snyder, Schmidt, & Kingstone, 2009) AM. Eye movements were not monitored in either study although Snyder et al. (2009) suggest this might matter. Here participants detected peripheral targets (up, down, left or right) using a manual keypress response following a peripheral, non-informative stimulus that was either ignored (Experiment 1) or detected (Experiment 2). In additional experiments, participants made saccades to peripheral targets after either ignoring a peripheral cue (Experiment 3) or looking at it and returning to center (Experiment 4). All studies showed evidence of IOR but no evidence of AM, using responses to un-cued adjacent locations as a point of reference. We conclude that previous reports of AM are spurious and are not driven by the presence (or absence) of eye movements.

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About the differential influence of eye movements and blinks on task solving in gaze cueing

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In cueing paradigms subjects often have to keep fixating a certain display region to avoid interplay between covert attention shifts and overt orienting. We measured eye movements of 23 subjects in a gaze cueing experiment to control for the continued fixation during trials. A centrally presented head gazed straight ahead before looking at one out of four objects after 1650 ms. Subjects had to respond to a color change of one object subsequent to the head's gaze shift. In about 16% of all trials participants made instruction-adverse saccades away from the head, resulting in more errors and increased reaction time. Furthermore, 10 of our subjects made blinks in more than 35% of the trials before the head's gaze shift. Comparing these "blinkers" to the remaining 13 "non-blinkers" revealed that blinkers made fewer saccades away from the head and fewer errors. No effects of blinking behaviour on reaction times were found. Our results show that participants have difficulties in suppressing spontaneous gaze behaviour in cueing paradigms, but that blinking might be a helpful strategy to act upon instruction.

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Shifts of attention in video game players and non-players

David Jule Mack, Helene Wiesmann & Uwe J. Ilg
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Video games are a widespread leisure activity but their behavioral effects are still heavily debated. Negative outcomes like increased aggressive behavior [1] have been shown as well as beneficial effects like faster reaction times [2].

Previously, we found shorter saccadic reaction times in video game players (VGPs) in an oculomotor task. In a follow-up study we used a cued visual attention task [3] with varying cue lead times (CLTs) to monitor the time course and benefit of shifting attention towards a cued location. We hypothesized that VGPs shift their attention faster than non-VGPs, which should lead to a superior performance and an earlier CLT of peak performance in these subjects.

As expected, VGPs performed better. However, they did not differ from non-VGPs in their CLT of peak performance. Our results suggest that VGPs do not shift their spotlight of attention faster but that they assess stimulus properties more efficiently. Therefore, they acquire more information in the same amount of time than non-VGPs, which in turn leads to a more informed decision, and thus, a superior performance.

[1] Anderson et al., Psychological Bulletin, 2010.
[2] Hubert-Wallander et al., WIREs: Cognitive Science, 2010.
[3] Nakayama et al., Vision Research, 1989.

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Magic for All Ages: Children and Adults Respond Differently to Misdirection

Robert Teszka & Gustav Kuhn
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Magician's tricks use a variety of cues to take advantage of the attentional system in order to misdirect the audience. The effects are strong and robust, and do not require complex experimental designs. For this reason, magic is a useful tool for studying attention in an ecologically valid way. The same trick is often performed differently for children and adults; it is assumed that the two groups respond differently due to different top-down knowledge about magic or attentional cues. This experiment investigated these potential developmental differences by showing children (aged 5-8) and adults video of the same magic trick. Their eye movements were recorded while they watched, and they answered a questionnaire measuring their conscious awareness of events in the magic trick. We find a marginal difference between children and adults in reporting events from the trick, and a significant difference in average saccade amplitude over the whole video. We discuss further eye movement analyses and interpret the results with respect to differences in top-down knowledge between children and adults.

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Spatial distribution of fixations can reveal process characteristics underlying prospective memory

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Prospective memory (PM) describes the delayed execution of intended actions. In PM research, there is an ongoing debate whether processes involved in solving a PM task are spontaneous or strategic. In the current study, 22 participants inspected digitized paintings and their eye movements were recorded. Image inspection was done under the premise of either free viewing, visual search, or to complete a PM task. Spatial gaze behaviour was analyzed by exploiting Voronoi diagrams of fixation positions. Skewness of Voronoi cell size distributions (skV) signifies layout of fixations on a given stimulus, with lower values indicating distributed scanning, while higher values denote clustered inspection of details (Over, Hooge & Erkelens, 2006). Our results demonstrate that missing the PM task is related to relatively high skV, similar to that during free viewing. When successfully completing the PM task, average gaze behaviour is between free viewing and visual search. Additionally, we found individual differences in skV between low and high PM performers: the former had smaller skV values than the latter. This pattern suggests that strategic search for the PM cue outwits its spontaneous finding. Strategy use seems to be different on the individual level.

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Spatial-temporal characteristics of saccadic LP at the presentation of target and distracting stimuli

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For successful goal-directed behavior in everyday life, it's crucial to attend relevant stimuli in the visual field while ignoring distractor elements. The objective of this study was to estimate dependence of saccadic LP at the stimulation of dominant and subdominant eye in modified version of oculomotor capture task. Our findings show that when target and distracting stimuli were presented in one visual semifield at the distance of 5 degrees and visual information of the stimulus projected to one hemisphere, LP of voluntary correct saccades was shorter (on 30 ms) but in the same time the number of erroneous automatic saccades was bigger (more then 50%). It can be explained from positions of Posner and Rizzolatty theory of attention from one side and oculomotor competition processes from the other. Saccadic LP were shorter when stimuli were presented to the dominant eye from the left visual semifield in comparison with subdominant eye. Erroneous automatic saccades on distracters appeared in the case of decreasing of LP at 30-40 ms in comparison with correct saccades. We supposed unsuccessful suppress of saccade on distracting stimulus in this case.

The work was executed at the support of RFBR (the projects No. 11-06-00306 and No. 12-04-00719)

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Investigating the role of event structure and task goals on oculomotor behaviour and change blindness when observing CCTV footage

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Change-detection (CD) studies have rarely used dynamic videos as stimuli. We are investigating the influence of an unfolding event on change detection (CD) by testing how task goals and a video's event type affected CD and inspection. Two videos, simulating CCTV footage alternating between two cameras, differed only briefly when a crime did or did not occur. Starting concurrent with the crime, in both videos a target change occurred: two people, one of whom was the thief in the crime video, switched locations. Fifty participants were instructed to look for a crime, fifty to look for something unusual and fifty to watch the video. Event and instruction did not affect CD (24% overall) but did affect eye movements. Moreover, CD and eye movements were related. Observers looking for a crime made more fixations on the target and fixations of shorter duration overall. Observers of the crime video made fewer fixations before the crime and fixated the target more during the crime. Participants demonstrating CD had longer and more fixations on the people who changed before, during and after the change, which we interpret as indicating more cognitive processing. Future studies will dissociate the change from the crime both spatially and temporally.

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Comparison of visual attention and eye movement during penalty kick of football among experienced, novice and inexperienced football players

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We have investigated the eye movement for predicting a direction of ball at the moment of penalty kick (PK). Stimulation of the scene of PK has been displayed on the screen of the PC, those scenes were recorded prior to the actual situation in the field of football PK. Eighteen male subjects, aged around 20 years, having normal vision and physical and mental conditions were done the experiment. Six of them were not experienced any sport (Novice), other six of them have played other sports (Other Sport), the other six have played football as a field player (Field). The subjects were asked to predict directions of ball. Directions of ball were divided into six positions according to a goal mouth. Prediction of a direction in the six positions was also asked to all subjects. Meantime Eye movements were recorded by the EMR-9 (NAC) head-mounted system. Comparison of eye movement between Novice and Field, and between Field and Other Sport were done by one allocation ANOVA horizontally or vertically. All P-values are statistically significant although variances within group are almost equals. Further prediction accuracy rates were as follows in better order: Field Player (52.85%), Sport Player (37.51%), and Novice Player (26.85%).

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Posters

Mental Load and Stress

Wednesday, August 14, 12:00 - 13:30

Room: Stora salen (2nd floor)

Interaction between workload of hazard perception and individual's executive functions: pupillometry in a simulator study among novice drivers

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Driving is a complex task that requires higher cognitive control, also referred to as executive functions (EF) (e.g., attention, inhibition, working memory). Novice drivers are involved in a disproportionate number of car-accidents. Hazard perception failures are a prominent cause of these accidents. Although it has been suggested that in a hazardous situation the drivers' mental workload increases, few studies have directly investigated the impact of hazardous traffic situations on workload. It can furthermore be hypothesized that this impact is moderated by EF, with increased EF leading to smaller increases of workload when hazardous situations are encountered. To test these hypotheses, novice drivers drove a simulated ride that contained different types of road hazards. Pupil size and blink data served as measures of workload. Hazard induced workload was calculated by the changes and change rates in average pupil size and blinking between the period of encountering a hazard relative to a pre-hazard period and a post-hazard period. Executive functions were assessed with computerized tasks. For each hazard, repeated measures ANOVAs were carried out to evaluate (1) hazard induced changes of pupil size and blinking, and (2) the relation of executive functions with these changes. The results and implications will be discussed.

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The Effect of Sound Environments on Oculomotor Control, Stress, and Performance

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This study is the third within the project Sound, Music, and Eye Movements, and results from the two previous studies examining reading for comprehension revealed no effects on eye movements such as fixation durations and saccade amplitudes with regards to sound environments. Therefore, other eye movement measures were tested in the current study, namely oculomotor control. Participants performed an anti-saccade task during eight sound environments with different types of non-linguistic distraction, while stress was measured using GSR and pupil dilation. Performance was evaluated by the participants after each sound environment, and an EPQ-R personality test and questionnaire about specific preferences regarding music and noise exposure was completed after the antisaccade task. Results from the current study suggest that oculomotor control is affected by disturbance, with highly significant decrease in correct eye movements (mean correct) in most "negative" sound environments (e.g., crying baby) compared to the control condition (silence), and no significant difference in most "positive" ones (e.g., a Mozart sonata). However, contrary to the hypothesis, a flowing river showed negative effects, and traffic noise showed no effects, compared to the control condition, which suggests that familiarity plays an important role in the level of disturbance.

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Background Music Impact on the Efficacy of Working Memory

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Researchers suggest that listening to classical music prior to task performance fosters cognitive processes,. However, types of music and the influence of background music to task performing have not been explored. To examine this, a working memory task (pattern transformation) was performed under classical music (N =16), favorite music (N = 20) and no music (N = 19) conditions with eye-tracking measurement. Pupillary response, whose amplitude provides a good reflection of task-induced processing load, is considered as a sensitive and reliable index. Results revealed that 1) favorite music condition exhibited better performance than no music condition and 2) during the information processing of the sub-task A the pupillary dilation from favorite music group is smaller than from classical music group and no music group. What's more, the increasing pupil size trend was also displayed. 3) When reaching to the deciding point, all participants from three conditions exhibited no difference in pupillary dilation though the pupillary dilation size is significantly bigger than the size during information loading process. The results indicated that participants from favorite music condition spent the least effort in loading information, whereas participants spent similar amount of effort when they were solving the cognitive task.

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Cognitive load increases drift in repetitive eye and finger movements

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The ability to produce sub-second time intervals is crucial to many daily activities, yet the role of cognitive control in this time range remains inconclusive. We tested the role of cognitive control in timing by assessing its influence on moment to moment variability and in maintaining long term stability, respectively. Low cognitive load corresponded to a simple and repetitive spatial sequence, while high cognitive load was induced by having participants produce a pseudo-random spatial sequence. In separate sessions, the tasks were either performed by shifting eye fixation between three dots on a screen, or with finger movements tapping on three keys on a musical keyboard. Thirty students were tested in all conditions, and reproduced intervals between 524 ms and 1431 ms. Pseudo-random action increased long term variability in both eye and finger movements but had no effect on moment to moment variability. Moreover, we found high within effector consistency across trials, but no significant correlations in timing variability between finger and eye movements. The pattern of results suggest a hierarchical structure of temporal control with executive functions operating as a multimodal long term timing control device whereas moment to moment timing might be managed within dedicated effector control circuitry.

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Eye movements as a measure of cognitive load during hypertext reading

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Presented research examines the differences in cognitve load during reading of the hypertext and regular text. There's growing number of studies showing that complexity of hypertext can increase cognitive load and impede information processing. Unfortunately, cognitive load measuring techniques reported in these studies are mostly indirect. In our study we employed novel way of measuring cognitive load by assessing eye-movement patterns and pupil dilation during reading task performed in hypermedia or traditional environment. We hypothesized that hypertext will pose higher demands on the reader and increase cognitive load and expected to observe differences in both eye-movement patterns and pupillary response between readers of hypertext and regular text. The main results were consistent with our predictions. Time spent on text was longer for the traditional text and gaze shifting to the whitespace occurred more frequently with hypertext. Additionally we observed the negative impact of the number of links on the time spent on text. This results suggest that (a) regular text is read more carefully and probably better processed than hypertext (b) high number of links may cause disorientation (c) analysis of eye-movement patterns is a promising method of assessment of cognitive load in reading tasks.

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Effects of driving environment complexity and dual task on eye blink rate

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Eye measures have been shown to be relevant indicators of mental workload. Empirical results revealed a relationship between mental workload and eye blinks, depending on the task constraints. In a single-task, the blink rate seems to drop as a function of greater task complexity, while the opposite result has been found in a dual-task. The goal of this study was to examine the effect of driving-task complexity on blink rate, using a single versus a dual-task. For the experiment, 20 participants drove in 3 driving environment complexities: low (dual-carriageway), medium (rural-road) and high (urban-road). Each condition was presented alone, or associated with a vocal reaction-time-task to an auditory stimulus. Results showed a strong effect of driving-task complexity, as blink rate decreased from low to high environment complexity. By contrast and differing from previous research, the dual-task condition didn't affect blink rate. This suggests that reaction-time and driving-task were performed simultaneously, and that the reaction-time-task didn't affect the driving-task. The effects of a dual-task on blink rate might probably occur in case of attentional switching. It could be valuable to examine in a future experiment the effect of environment complexities on blink rate in a new dual-task paradigm: driving and mental-arithmetic.

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Posters

Pupillometry

Wednesday, August 14, 12:00 - 13:30

Room: Athen (ground floor)

Wavelet analysis revealed pupil size oscillation changes in fatigued drivers

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Increased slow pupil size oscillation or "fatigue waves" in fatigued individuals was reported by Lowenstein in 1963. Recently, Henson & Emuh (2010) used wavelet transformation to quantify the intensity of such oscillation in their fatigue experiment. This study attempts to validate the work of Henson & Emuh (2010) by applying their wavelet techniques on pupil data collected from 32 participants who drove on the actual road (30 km/h), up to the point of fatigue and microsleep. The oscillation strength, in Coefficient Magnitude (CM), from 4 wavelet frequencies (0.242 Hz, 0.104 Hz, 0.03 Hz and 0.02 Hz) was investigated using the Matlab Wavelet Toolbox. Statistical analysis was conducted to compare the CM readings for BP (Baseline Point before driving), MS (the point in time where the first 1-second microsleep occurs), as well as MS-4, MS-8 and MS-12 (4 minutes, 8 minutes, 12 minutes before MS). Results shown significant differences between BP, MS-12 and MS, particularly for frequencies 0.242 Hz ($F = 17.7$ (5,25), $p < 0.01$) and 0.104 Hz ($F = 11.18$ (5,25), $p < 0.01$). Hence, it is possible that real-time pupil oscillation measurement can be used to monitor driver fatigue.

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Time course analysis of pupillary response during the recall phase of an auditory digit-span recall task

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Using different memory load conditions, previous research has shown that pupil diameter decreased progressively with every digit recalled (Cabestrero, Crespo, & Quirós, 2009). Nevertheless, it remains unclear whether that pupil size reduction is due to the information unloaded from memory or merely to the time course. In order to shed light on that issue, the pupil size of 52 participants was recorded during an auditory digit-span recall task. Three load conditions were manipulated (low load —5 digits—, moderate load —8 digits—, and overload —11 digits—). Recall was paced at a rate of a digit for second. Additionally, in order to make similar the time course among conditions (11 seconds), recall phase was adapted for low and moderate load conditions. Differential values were calculated for each second of the recall phase referred to the values at the point of maximum load. Time course analysis revealed that the pupil size decreased progressively after the fifth digit release regardless of the load condition, suggesting that reduction of pupil size was an inherent consequence of the passing of time once the task is over.

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Pupil dilatation as an index of information processing in emotional n-back task

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Numerous studies have shown that during cognitive tasks pupillary diameter systematically dilates as a function of task difficulty providing a dynamic index of information processing. The aim of the present study was to examine the time course and amplitude of pupil responses in anxious (N = 30) and control sample (N = 30) while We recorded the pupil diameters of participants performing the an emotional n-back task. Participants were presented with a sequence of words and were required to indicate whether the word displayed at the given moment matched the emotional valence (positive or negative) of the one shown two words earlier. We expected more pronounced diameter change in the clinical sample, especially for trials with negative words. The work is in progress.

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Measurement errors of pupil diameter using corneal reflection eye trackers

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Pupil dilation is a useful non-invasive technique that allows to measure changes in cognitive load (Laeng, Sirois & Gredebäk, 2012). It is most often measured by corneal-reflection eye tracking devices. Few studies have assessed accuracy of pupil diameter measurement using eye tracking systems (Gagl, Hawelka & Huzler, 2011). The present study investigates the effect of gaze point on pupil size estimation by two common eye tracking systems (EyeLink and Tobii). Participants (n=44) were asked to do a simple object pursuit task, as a sphere displayed an elliptical trajectory filling the whole screen. Task demands were very low and the task has been achieved at constant luminance. In such conditions, there should be no systematic changes in pupil diameter. Nevertheless, systematic errors of pupil size estimation were found with both systems. Significant differences were primarily linked to horizontal gaze in Tobii systems, and vertical gaze for the EyeLink system (Brisson et al., in press). This presentation follows up initial results by studying whether error slopes differ for left and right eyes, compared to an average of both eyes. Results have implications for error correction, especially for task-elicited pupillometry, like gaze-contingent studies such as object tracking or reading.

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Pupil diameter does not correlate with fixation duration – or does it?

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A number of pupillometric studies have suggested that dynamic differences in pupil diameter correlate with different levels of cognitive intensity or excitement. Other studies have suggested a similar correlation between fixation duration and cognitive effort. Since both methodologies for hypothesizing about cognitive effort are contested, we examined if the two measures co-vary in eye-tracked observations of translators while performing a translation or text-revision task.

A plot representation of pupil diameter measurements inserted in a progression graph showing a participant's gaze path while translating/revising indicated that diameter size pulsates regularly throughout such tasks, with peaks occurring task initially, before final revision, and, occasionally, during the drafting phase, typically at intervals with no typing activity. From the point of view of validating the two micro-behavioural methodologies, the most interesting result was establishing whether or not the pupil diameter of translators and revisers co-varies systematically with fixation duration, such that the occurrence of larger-than-average pupil diameters correlates with longer-than-average fixations, regardless of what linguistic material they are fixations of.

We tested the assumption on six recordings of translation sessions in three different experiments, all of which are available in the CBS database of translation and post-editing process recordings.

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Measuring "Implicit" Emotions with a Combination of Pupillometry and Priming

Ewald Strasser, Astrid Weiss & Manfred Tscheligi
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The proposed measurement is based on priming and pupillometry. The priming part consists of faces with emotional expressions like fear and happiness. This stimulus is thought to interact with the current emotional state of the primed person. Interactions can be categorized on the continuum congruent to incongruent. Congruent interactions are interactions where the current state of the person matches the facial priming whereas primings that do not match the internal state of the participant lead to incongruent interactions. Further pupillometry is used to evaluate if the priming was perceived either as congruent or incongruent. The work of Laeng et al. [1] with the stroop effect indicates that congruency-incongruency can be extracted from the pupil dilation. Laeng et al. [1] showed that incongruency resulted in higher relative pupil dilation while congruency leads to low pupil dilation. Evidence from e.g. Laeng [2] lead also to the assumption that such basic appraisal processes do not only affect the dilation of the pupil but that they are also subconscious. A first pilot study which used pictures of the IAPS [3] to establish disgust in the participant and used disgusted and happy faces as primings showed results that are in line with our assumptions.

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Posters

Reading Studies

Wednesday, August 14, 12:00 - 13:30

Room: Stora salen (2nd floor)

A new child of dlexDB: childLex, a lexical database of children's print language in German

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We first introduced dlexDB, a German online database of written texts covering the 20th century during the ECEM 2009. dlexDB provides an interface to search for specific lexical and sub-lexical variables as well as word or character n-grams for over 100 million words in the underlying corpus. Due to the vast evidence that the childrens and adult's language differ from each other, we now introduce *childLex*, a lexical database compiled from a large collection of German children's books. childLex is a joint project of the Max Planck Institute for Human Development, the Berlin-Brandenburg Academy of Sciences, and the University of Potsdam. It intends to complement dlexDB with lexical norms for children. Both for dlexDB and childLex the same tools are used to enable a direct comparison of children's and adult's lexical measures. We compare word frequencies and sublexical measures for a data set of eye movements from students as well as lexical decision times from children and students for 4000 German words.

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Parafoveal processing of Chinese idioms

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The current study investigated parafoveal processing of three character Chinese idioms. These may form single lexicalised elements, and if so, they may be identified via single lexical entries (rather than multiple lexical entries corresponding to individual constituent words). If idioms are associated with single lexical entries we might expect parafoveal processing of them to operate over multiple words to a greater degree than non-lexicalised phrases. We tested this hypothesis in a boundary paradigm experiment where the boundary preceded an idiom or two word phrase (the target). The target was always comprised of a single character word followed by a two character word. Previews of the second word of the target were either pseudowords (two characters forming a nonword), or identities. Prior research using this paradigm has shown n+2 preview benefit only when word n+1 is a high-frequency character, which it was not in this study. Current analyses (based on 24 subjects) show n+2 preview benefit in both the idioms and phrases, with the effect being numerically larger in the idioms. This pattern suggests that multiword Chinese idioms may be parafoveally processed holistically to a greater degree than phrases, indicating that idioms are treated as single lexicalised elements.

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Spatial representations of previously encountered text: Processing to the left of fixation during reading

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The spaces between words serve as easily identifiable visual cues to a word's boundaries and are thought to play an important role in planning eye-movements during reading. Although much is known about how readers use the spatial layout of upcoming text, little is known as to how readers might continue to process the spatial layout of text that has been previously read (i.e. text to the left of fixation). The present research used a gaze-contingent technique in which upon fixating to the right of an embedded target word, the space preceding the target was filled with a letter (Experiment 1), or a letter within the target was substituted for a space (Experiment 2). Our findings reveal that changes to word spacing to the left of fixation influence eye-movement behaviour (as shown in increased reading times and regression probabilities), and that this left-of-fixation processing may be limited to information that is close to the currently fixated word. The results indicate that our spatial representation of text to the left of fixation is updated as we read.

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The role of capitals in parafoveal processing

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Hohenstein et al. (2010, JEP:LMC, 26, 1150-1170) found a semantic preview benefit for German nouns in reading. Given that a semantic preview benefit is hard to obtain in other languages, it may well be that the preview benefit is driven by the fact that German nouns are presented in capitals.

That is, capitalization of a word and with that its syntactic category can probably be extracted parafoveally rather swiftly. This may release processing resources to extract other features of the word (like semantic features) more quickly as well and hence a semantic preview benefit is more likely in German than in other languages.

The current study explored whether a difficult-to-obtain lexical preview benefit can be observed in another language than German, namely Finnish, when nouns are presented in capitals. More specifically, the current experiment explored whether the classical word frequency effect is stronger and can be observed earlier when Finnish nouns are capitalized in comparison to when they are not. Preliminary results showed that this indeed may be the case, but only after a certain amount of exposure to capitalized nouns in Finnish.

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Perceptual Span in Chinese Reading is Larger for Small Font Size

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While the font size invariance on saccade-target selection and the perceptual span is generally accepted for reading of spaced alphabetic text, it still remains open whether such invariance will hold for unspaced Chinese script. In the present study, we used the moving-window paradigm to test the effect of font size on the perceptual span in Reading of Chinese. In Experiment 1, we measured the perceptual span with visual masks similar to Chinese characters and a normal font size. Results showed that the rightward span extends beyond three characters which is larger than reported before. In Experiment 2, we instructed participants to read full line and moving window sentences in different font sizes. We found significant interactions for eye movement measures between viewing conditions and font size, indicating that large font size decreased the amount of text that is processed. We propose that the perceptual span in Chinese is flexible; it is strongly constrained by language-specific properties such as lack of word spacing.

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Using the SWIFT model to investigate parafoveal processing of word n+2

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To efficiently guide eye movements during reading, information is sampled from a region of text that spans from about 4 letters to the left to 15 letters to the right of fixation [Rayner, Well, & Pollatsek, 1980, Perception & Psychophysics, 27, 537-544]. How word processing is coordinated across this span is not fully understood and reading models postulate competing approaches to this end. However, computational implementations of such models can help to unravel the underlying processes investigating their internal behavior with respect to certain empirically established outcomes.

We used the latest version of the SWIFT model [Schad & Engbert, 2012, Visual Cognition, 20, 391-421] to test different implementations of the processing span. Based on distributed attention, the variants were compared and evaluated on their performance in a gaze-contingent reading task manipulating preview of word n+2. We present results of preview effects from simulated data of the best-fitting models. Moreover, we also present analyses of the model dynamics for parameter variations that explained modulations of parafoveal processing of word n+2. Simulations revealed that the SWIFT model could reproduce various n+2 effects. Moreover, we identified model assumptions within the SWIFT framework that seem interesting for future experimental research.

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Patterns of on-line resource allocation to increased inference-making demands: A comparative eye movement study

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Bridging inferences are crucial for the construction of coherent text representation. However, we know very little about how children and adults make such inferences during reading. We measured eye movements as adults and children read texts to investigate the on-line processing of bridging inferences. We hypothesized that adults are more sensitive than children to inference demands, allocating their processing resources accordingly. Thirty-four adults and 61 children (8-11 years) read paragraphs in three different conditions. The control condition provided explicit information for the inference, the paraphrase condition provided contextually-supporting information and the inference condition provided less contextual support. For measures indicative of early processing, only adults showed longer looking times in the paraphrase and inference condition, relative to the control. For measures indicative of later text processing, adults' reading times were longer in the inference condition than in the paraphrase condition. Children showed longer reading times in the inference and paraphrase conditions than the control condition. Consistent with skilled readers building a coherent text representation as they read, adults responded immediately to increased inference demands both in initial and later text processing. Children only responded partially in later processing measures, suggesting they form a less coherent text representation as they read.

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A cognitive model interfacing eye movements with parsing

Felix Engelmann, Shravan Vasishth, Ralf Engbert & Reinhold Kliegl
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Reichle et al. (Psychonomic Bulletin & Review, 2009) proposed two kinds of interaction between post-lexical processing and oculomotor control: (1) "slow integration failure": A time-out regression when post-lexical integration is lagged; and (2) "rapid integration failure": A regression when integration fails. Boston et al. (Eye Movement Research, 2008; Language and Cognitive Processes, 2011) showed that memory retrieval (Lewis & Vasishth, Cognitive Science, 2005) and syntactic surprisal (Hale, NAACL, 2001; Levy, Cognition, 2008) are significant predictors of eye movements in the Potsdam Sentence Corpus.

We implemented the proposed interaction of the first kind in the cognitive architecture ACT-R and evaluated the model on the Potsdam Sentence Corpus using pre-calculated values from Boston et al. (2008, 2011). The model's prediction of 11 fixation measures including second-pass durations and regression rates was grouped by classes of word frequency and fitted to the data with a resulting root-mean-square error of 0.206 and a correlation R of 0.9.

Based on this evaluation we present work in progress that uses the parser of Lewis & Vasishth (2005) for a direct interaction of eye movement control with parsing rules and implements rapid integration failure resulting in long-range regressions guided by active repair attempts.

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Immediate and delayed effects of word frequency and word complexity on lexical processing: Evidence from eye movements

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Frequency and complexity are two basic attributes of characters. However, whether the two factors exert an immediate or delayed influence on lexical processing in Chinese reading is not very clear. We used verb-noun pairs that were embedded in sentences. We manipulated frequency (high or low frequency) and complexity (high or low complexity) of a verb which immediately preceded a noun. The results showed that word frequency had played a privotal and immediate role in Chinese reading, with shorter and fewer fixations and higher skipping probability on high-frequency than on low-frequency verbs. Word complexity also affected word processing immediately, that is, low-complexity verbs needed shorter fixation time to be processed and had higher skipping probability than high-complexity ones. There was no immediate but delayed interaction between word frequency and complexity, specifically, when verbs were of high-frequency and low-complexity, there were shorter and fewer fixations on nouns than when verbs were of low-frequency and low-complexity; meanwhile, there were longer and more fixations on nouns when verbs were low-frequency and low-complexity words than when verbs were low-frequency and high-complexity words, which showed a reversed and delayed complexity effect. The delayed effects suggested that there was post lexical processing in Chinese reading.

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The subordinate bias effect in Chinese lexical ambiguity resolution

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The present study investigated the subordinate bias effect (SBE) of Chinese homographs using both low frequency and high frequency unambiguous words as the controls. When the preceding context supported the subordinate meaning in reading a sentence, fixation durations were longer on biased homographs as compared with the unambiguous words. In addition to the account of accessing multiple meanings, studies have suggested that the SBE may be the consequence of taking the subordinate meaning of homographs as a low frequency word, rather than the competition of the dominate meaning to the subordinate meaning (Sereno et al., 2006). To resolve this debate, this study manipulated three types of target words in a biased context: low frequency biased homographs, low frequency and high frequency unambiguous words. Thirty participants read a total of 72 experimental and 24 filler sentences intermixed randomly. The results showed the significant SBE effects of gaze duration, total viewing time, and go-past time on target words with low frequency controls. The Chinese SBE effect suggests that readers access multiple meanings of homographs, and both meaning dominancy and contextual biasing determine the meaning activation and competition during lexical ambiguity resolution.

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Early versus late lexical processing during reading: Evidence from eye movements

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The present study was designed to examine the processes underlying word identification during reading, by manipulating both lexical and visual aspects of the text. Specifically, participants' eye movements were monitored while they read sentences in which high-frequency and low-frequency target words were presented either normally (i.e., the normal condition) or with reduced stimulus quality (i.e., the faint condition), or with alternating lower and upper case letters (i.e., the case-alternated condition). Both the stimulus quality and case-alternation manipulations interacted with word frequency for the gaze duration measure (i.e., the cumulative duration of all first-pass fixations on the target word), such that the magnitude of word frequency effects was increased relative to the normal condition. However, stimulus quality (but not case alternation) interacted with word frequency for the early fixation time measures (i.e., first fixation, single fixation), whereas case alternation (but not stimulus quality) interacted with word frequency for the later fixation time measures (i.e., total time, go-past time). We interpret this pattern of results as evidence that stimulus quality influences an earlier stage of lexical processing than case alternation, and we discuss the implications of our results for models of eye movement control during reading.

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Repetition Effect within a Short Stories: An Eye Movements and Linear-Mixed Models study on a Spanish Corpus

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Flexible thinking, the ability to combine arbitrary processes, is a hallmark of human thought. The studies on reading are vehicles to understand these capabilities. In particular, Repetition Effects were used to study word encoding and memory processes. Here we extend previous results comparing reading times between words in two successive paragraphs, to repetitions of a word within natural texts -short stories (3000 words)-.

We analyzed the evolution of fixations over successive repetitions that naturally appears in a text, studying average gaze durations and applying Linear Mixed Models. We found a decrease on fixation durations in words with low corpus frequency, but not for high frequency words, and both curves converged after 5/6 repetitions. The diminishing of gaze duration vary continuously with frequency, and depends on the distance between repeated words. We also found that this effect were not present in repetitions of words that share lemma but not the form.

The results clearly showed repetition effects within the same natural text, and add new arguments on the discussion of the sources of the repetition effect. Also, this is one of the first studies using Linear-Mixed Models in a spanish corpus (Fernandez et al, 2013).

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Foveal Load Modulates the Parafoveal Preview Cost in Chinese Reading

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The purpose of this study is to determine whether foveal processing difficulty can influence the preview effects of the upcoming parafoveal word during Chinese reading. Studies using the boundary paradigm usually address that the similar properties of a preview word can facilitate target word processing, referring as preview benefits. Kliegl et al. (2012) suggested that preview effects were a complex mixture of preview cost and preview benefit, varying with preview space and preview time related to process the upcoming words. The present study manipulated the frequency of foveal word n and the visibility of the parafoveal word n+1. We demonstrated the frequency effect on word n and the identical preview benefit on word n+1. In addition, there was an interaction between word n frequency and word n+1 preview effect, showing a larger preview effect with a high-frequency word in foveal vision. Such phenomenon was due to the cost of incorrect preview with a high-frequency foveal word. These findings demonstrate the modulation of foveal load on both parafoveal preview cost and benefit.

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Does Chinese Compound Word Structure Influence Where to Move the Eyes?

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For alphabetic language scripts, it has been demonstrated that high-level linguistic variables do not influence where readers move their eyes (Rayner K. (2009). The thirty-fifth Sir Frederick Bartlett Lecture: Eye movements and attention in reading, scene perception, and visual search. Quarterly Journal of Experimental Psychology, 62, 1457-1506.). Written Chinese, as a kind of ideographic writing system, differs from alphabetic writing system. For example, Chinese compound words can be divided into different kinds of constructions according to semantic relationships between constituent characters. Two experiments were conducted to investigate the influence of compound words structure on landing positions during Chinese reading in this study. In Experiment 1, we manipulated constructions of two-character compound words (coordinate and attributive structure). In Experiment 2, compound words pairs shared the first constituent character but with different constructions (coordinate or attributive) were used as target words. The results showed that Chinese readers targeted their initial saccades to word center in single fixation cases and to word beginning in multiple fixation cases. However, the landing positions were very similar for coordinate and attributive two-character Chinese compound words, indicating that Chinese word structure does not influence on initial landing positions during Chinese reading.

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The Role of Prediction on Processing Morphological Informaion in the Parafovea

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We will examine whether syntactic prediction could influence eye movement behaviour in reading. We will report two experiments in Turkish where the morphology of the upcoming verb was predicted from previous sentence context. In Turkish negation is marked with a specific morpheme at the verb. Phrases like 'nobody' will require it's licensing word to be negative. In the first experiment, using sentences that start with nobody we created an expectation for a negative verb and compared it with sentences that start with somebody where there was no such requirement. Licensing verbs for sentence initial NP was either at the embedded verb or at the main verb. If readers are more likely to access morphological information from the parafovea when this information is predicted, this should reflect itself in skipping rates and following fixation durations on the parafoveal word. The second experiment we manipulated syntactic prediction by using specific case markers at sentence initial nouns, which require certain verbs. We want to see if the readers are more likely to benefit from parafoveal information before reaching the verb, where the verb was either typical or not. We will discuss the implications of these results for lexical access in reading models.

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The Effect of Phonetic Radicals on Identification of Chinese Phonograms

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For Chinese characters, semantic information is linked more closely with the orthographic than the phonetic information, whether there is a phonetic activation in the semantic access of Chinese character is controversial. To investigate this issue, Chinese phonograms were used in the present experiment. The Chinese phonograms have phonetic radicals, which mostly have the same pronunciation with the phonograms. Two eye movement experiments were conducted to investigate whether the phonetic information of the phonetic radicals play an important part in the processing of phonograms. A 2(position of phonetic radicals) ×3 (pattern of stroke removal) within-participants design was used to examine the phonetic radicals on identification of Chinese left-right structure and up-down structure phonograms in Experiment 1 and 2 respectively. There was a significant interaction between the two factors in both experiments (ps< .001). When the phonetic radical was on the right side or down side of the character, the fixation duration of the characters with ending strokes removed was longer than that of the characters with beginning strokes removed. It indicates that if the ending strokes removed are the phonetic radical, the stroke removal effect will disappear. The result demonstrates phonetic radicals play an important role in identification of Chinese phonograms.

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Both syntactic function and structural position play an active role in on-line correferencial processing

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Goal: contrast the effect of syntactic function and structural position in the processing of null and over subjects in European Portuguese. Method: in a Visual World experiment, participants listened to complex sentences – main clause followed by a subordinate temporal clause – while viewing pictures where the subject and the oblique-object of the main clause were depicted. The subject of the subordinate clause was always a null or an overt pronoun that could be interpreted as retrieving one of the previously mentioned entities. We used main clauses with both canonical and non-canonical orders: SVO and OVS. So, the subject could be in the highest syntactical-structural position, or in a lower position. Results: in the null pronoun condition, the subject received more looks in the SVO-condition (p=0,035 [1000ms-1200ms]; p=0,025 [1200ms-1400ms]), but in the OVS-condition, it was the object that received more looks, though marginally (p=0,057* [800ms-1000ms]). With the overt pronoun, in the SVO-condition, the object received more looks (p=0,043 [200ms-400ms]), but in the OVS-condition, the subject received more looks (p=0,052* [200ms-400ms]), though marginally. Conclusions: our results support a multiple-constraint approach of correferencial processing, in line with Kaiser (2006), and Kaiser, Trueswell (2008), and challenge Carminati's (2002) or Grosz, Joshi and Weinstein's (1995) views.

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Grammatical gender does not lead to similarity-based interference

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It has been shown that the definiteness feature on noun phrases held in memory leads to an increase in

processing difficulty when retrieving one of these NPs at a later point in the sentence (so-called encoding interference, Gordon et al. 2006). Does a gender feature overlap also cause encoding interference? We ran a high power eyetracking experiment to investigate this; 126 subjects were shown German sentences consisting of

relative clauses which had a masculine or feminine subject, and a masculine or feminine noun in a relative clause modifying the subject, followed by a a verb and a gender-neutral reflexive (sich). If gender induces encoding interference, shared gender of the two NPs should lead to longer fixations at the regions where one of the two subject NPs are retrieved, i.e., the relative clause verb, the main clause verb and the reflexive.

However, no slowdown was observed either at the verb or the reflexive. The implications of this finding for reflexive processing will be discussed.

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Using eye movements to understand cognitive processing during copying from the board

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Although copying text from a board seems trivial, the task itself is psychologically complex. It involves a series of sequential visual and cognitive processes, including visual encoding, construction and maintenance of a mental representation in working memory, followed by production of the representation in written form. We measured eye movements while participants produced written copies of isolated words that were presented on a wall-mounted-screen. We manipulated word-length and whole-word frequency of to-be-copied text to investigate whether these properties influenced encoding, representation and written production. Data for 14 adult skilled readers showed a word-length effect during both encoding and production stages; increased total encoding duration was demonstrated for low compared to high frequency words. Lack of frequency effects in production was likely due to written word production being based on a complete lexical representation (rather than partial word representations encoded across successive encoding episodes). Encoding measures, combined with gaze transfer patterns (head movements between the original text and the participants' written copy) during encoding, production and checking, seem potentially sensitive measures in a board-copying task. We believe that this preliminary investigation demonstrates that this approach offers a potentially useful paradigm to investigate adults' and children's copying behaviour in a classroom environment.

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An Additive Mixed Model Analysis of Frequency Effects on Fixation Durations in Reading

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Fixation durations in reading reflect effects of perceptual, language-related, and oculomotor conditions. Many of these effects are tied to continuous variables; often they are not linear and sometimes they are not even monotonic (e.g., the frequency effect of the fixated word). Generalized additive mixed models (GAMMs) allow for a flexible modeling of response surfaces. They incorporate splines (smooth functions) as fixed effects as well as random effects due to, e.g., subjects and words. Frequently, it is of interest whether a highly irregular response surface (e.g., the joint effect of the frequency of the current and the previous word) can be expressed as a simple addition of the two marginal splines or whether the surface also requires their interaction. There is the option of a canonical decomposition (SS-ANOVA), typically implying a certain basis and penalty for the spline and therefore (possibly) ignoring prior knowledge about the data. We propose a new method that incorporates prior knowledge into the spline fit by performing the decomposition post-hoc. We showcase the performance of our method by cross validation on artificial data and with an analyses of the frequency effects on fixation durations during reading of the Potsdam Sentence Corpus.

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Two stages of processing during the segmentation of overlapping ambiguous strings in Chinese reading

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In two experiments, we investigated how Chinese readers group characters into words during Chinese reading using overlapping ambiguous 3-character strings. The middle character of the string could constitute words with both the first character and the third character. In Experiment 1, we adapted a character-naming task to the middle character of the overlapping ambiguous strings in cases where the middle character was a polyphone. Participants preferred to name the middle character with the pronunciation it assumes when grouped into the higher-frequency word, regardless of the higher-frequency word's position (left-hand or right-hand). In Experiment 2, critical 3-character strings were embedded in two sentence frames that only differed after the critical 3-character strings, and we observed participants' eye movement when they read these sentences. Both second-pass reading time and regression-in probability indicated that the higher-frequency word wins the competition more often. Moreover, reading times was longer in the disambiguating region when it was congruent with the higher-frequency segmentation than when they were incongruent. These results suggest that there are two stages of processing during Chinese word segmentation: an initial stage of processing based on local information such as word frequency, and a second stage based on global semantic information.

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Further Investigations of Inhibitory Stroke Neighbor Priming in Chinese

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Recent research shows that prior exposure to a word's orthographic neighbor earlier in a sentence increases fixation times for that word, and so appears to slow the process of word identification that occurs naturally during reading (Paterson et al., 2009). Moreover, a similar inhibitory priming effect has been observed in fixation times for Chinese characters that are stroke neighbours (and so differ by only one or two character strokes) when one character is encountered a few characters ahead of the other in a sentence (Tian et al., 2011). The present study extended this research in Chinese by investigating priming effects between stroke neighbours that are phonologically related or unrelated. The findings show increased fixation times for target characters that follow either a phonologically related or unrelated prime (compared to a matched non-stroke-neighbour character). Moreover, these priming effects were not modulated by the relative frequency of the prime and target characters. The findings provide further evidence that stroke neighbour priming occurs naturally when reading Chinese, is not mediated by phonological similarity or the relative frequency of prime and target characters, and influences fixation times on characters. We discuss these findings in relation to current models of eye movement control while reading.

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Using E-Z Reader to Examine the Concurrent Development of Eye-Movement Control and Reading Skill

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Compared to skilled adult readers, children typically make more, longer fixations, shorter saccades, and more regressions, thus reading more slowly (Blythe & Joseph, 2011). Recent attempts to understand the reasons for these differences have discovered some similarities (e.g., children and adults target their saccades similarly; Joseph et al., 2009) and some differences (e.g., children's fixation durations are more affected by lexical variables; Blythe et al., 2009) that have yet to be explained. To evaluate hypotheses about the concurrent development of reading skill and eye-movement behavior, we completed simulations using the E-Z Reader model (Reichle, 2011; Reichle et al., 1998) to examine various eye-movement phenomena in adults versus children. These simulations suggest that the primary difference between children and adults is their rate of lexical processing, and that different rates of (post-lexical) language processing may also contribute to some phenomena (e.g., children's slower detection of semantic anomalies; Joseph et al., 2008). The theoretical implications of this hypothesis will be discussed, including possible alternative accounts of these developmental changes, how reading skill and eye movements change across the entire lifespan (e.g., college-aged vs. older readers), and individual differences in reading ability.

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Different binocular foveal strategies in reading; younger and older readers

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We investigated the binocular foveation strategies in reading, in younger and older adults. Eye-movements were recorded as 15 younger (Mean age 25 years) and 12 older adults (Mean age 75 years) read the 5000-words of English text used in the Edinburgh 5-Language Corpus, on a computer screen. The younger and older readers were globally similar in the eye-movement behaviours studied, except that the older readers employed a significantly larger proportion of uncrossed binocular fixations (i.e. with the left eye's fixation to the left of the right eye's fixation). We interpret these data in terms of a theory of binocular fixation disparity [see Shillcock, R., Roberts, M.A.J., Kreiner, H., & Obregón, M. (2010). Binocular foveation in reading. Attention, Perception & Psychophysics, 72, 2184-2203, for further details], and suggest that uncrossed fixations are important for binocular fusion in older readers.

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Perceptual Span in Kannada

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Perceptual span (effective visual field) varies across languages depending upon their orthographic nature. Perceptual span for English is 3-4 character spaces to the left of fixation and around 14-15 character spaces to the right of the fixation. Perceptual span for Chinese is one character space to the left and three character spaces to the right of the fixation. Language that are read left to right have been found asymmetric perceptual span towards right and the languages that are read right to left have asymmetric perceptual span towards left. In the present study, we report the perceptual span for an Indian language Kannada with an alphasyllabary writing system written left to right. This is the first report of perceptual span for an alphasyllabary to the best of our knowledge.

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A rapid effect of stimulus quality on the duration of individual fixations during reading

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We employed a variant of the single fixation replacement paradigm (e.g., Yang & McConkie, 2001) to investigate the effect of stimulus quality on fixation duration during reading. Twenty undergraduate students read text passages in preparation for a comprehension test. The text was printed in a light gray colour for half of the passages, and in a dark gray colour for the other half. The passages' background colour was a middle gray colour, such that the light gray and dark gray text was similarly readable. Participants' eye movements were monitored, and for randomly-selected critical fixations the passage background colour was changed to black or to white. These changes resulted in an increase or decrease in the contrast of the text, depending on its colour (i.e. light gray vs. dark gray). The middle gray background colour was restored during the saccade following the critical fixation. The duration of critical fixations was lengthened greatly when the text contrast was decreased but was lengthened only slightly when text contrast was increased. Because both of the contrast-change conditions involved an equivalent change in low-level luminance, the present findings point to an immediate effect of stimulus quality on the duration of individual reading fixations.

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Parafoveal preprocessing in reading revisited: Evidence from a novel preview manipulation

Benjamin Gagl, Stefan Hawelka, Fabio Richlan & Florian Hutzler
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The present sententence reading study investigated parafoveal preprocessing by means of the classical invisible boundary paradigm and a novel manipulation of the parafoveal preview. The manipulation, that is, visual degradation, did not interfere with word recognition processes of the target. Thus, we had a proper baseline to which we could relate our findings which were as follows: (i) The final letters of an upcoming target words are preprocessed, when the preceding fixation was in close proximity of the target word. (ii) The preview of the initial letters of an upcoming target word yielded similar preview benefits as previewing the whole word when the initial letters imposed high constraints on the set of potential target words.

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Scanpath based n-gram models for predicting reading behavior

Abhijit Mishra, Pushpak Bhattacharyya & Michael Carl
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Predicting reading behavior is a difficult task. Reading behavior depends on various linguistic factors (e.g. sentence length, structural complexity etc.) and other factors (e.g individual's reading style, age etc.). Ideally, a reading model should be similar to a language model where the model is built upon a fixed number of overlapping word sequences (n-grams). But it would be difficult to decide what kind of representation of gaze data (unit of n-grams) would correlate more with cognitive effort associated with reading. Moreover, the randomness associated with gaze data also accounts for data sparsity, making it difficult for gaze based n-gram models to handle real test scenarios.

It has already been seen that some important eye-movement phenomena are captured better by scanpaths than considering individual fixations, saccades and pauses. In this talk, we propose and validate an n-gram based gaze model for reading. The units contributing to each n-gram will be scanpaths (in a temporal order). We describe different scanpath extraction techniques and chose the one which minimizes the entropy/perplexity of the system. To handle data sparsity, we cluster the scanpaths into several groups, assign them with ids and use n-grams of cluster-ids instead of taking exact scanpaths.

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The influence of inter-word spaces information on eye movements during reading.

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In reading the pattern of eye movements is a consequence of learning strategy to use inter-word spaces to plan fixation locations. Any violation of inter-word spaces structure may change oculomotor strategies during reading. The goal of our experiment was to study the differences in strategies in the conditions when the word-boundary information was difficult to extract. Eleven normal texts of medium complexity were used. Every text was modified in the following way: 1) inter-word spaces were deleted; 2) regular inter-letter spaces were inserted; 3) the first letter of every word was moved to the last letter of the previous word 4) inner letters of words were mixed in random order 5) random spaces were inserted in every word. Eleven observers (age range 17—31) were tested. The eye movements during reading were registered using iView X Hi-Speed 1250 technique. The results showed that the pattern of eye movements changed differently depending on the type of text modification. For all modified texts the fixation locations shifted to the problem areas of the text to distinguish real/false inter-word spaces. The parameters of eye movements showed that the most difficult was the fifth type with random spaces inserted in every word.

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The effect of spacing on preview effects for one-character and two-character words in Chinese reading

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In an eye movement experiment investigating Chinese reading we compared parafoveal preview benefit for sentences in either familiar, unspaced format or with spaces inserted between the words. Using the boundary technique (Rayner, 1975), the preview of a one character or the first of a two-character target word was presented either normally or was replaced by a pseudocharacter. The boundary immediately preceded the target in the unspaced format, or in the spaced format either preceded the blank space before the target word, or immediately preceded the target word. The two locations of the boundary allowed us to observe preview effects whilst controlling effects due to acuity limitations. Results indicate that word spacing increased the parafoveal preview benefit but only for the one character target words. In all likelihood, the incorrect preview of the first character prevented parafoveal processing of the ensuing character(s), effectively nullifying any benefits from the spacing. Our results suggest that word boundary demarcation allows for more precise focusing of attention in the parafovea.

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Posters

Binocular & 3D eye tracking

Thursday, August 15, 12:00 - 13:30

Room: Stora salen (2nd floor)

Monocular and binocular reading performance in subjects with normal binocular vision

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Purpose: To quantify the differences in reading performance between monocular and binocular reading in subjects with typical reading skill and binocular vision status.

Methods: In a balanced repeated measures experiment 27 subjects read standardized paragraphs of text under monocular and binocular conditions. Reading speed and eye movements were recorded with an eye tracker and the connection between reading condition, binocular measures and ocular dominance was evaluated.

Results: The preliminary results show equal reading speed at monocular and binocular reading. Mean monocular reading speed was only slightly lower (2 %) than binocular (not significant). Monocular reading showed significantly increased fixation duration (8 %).

Conclusion: The preliminary findings indicate that monocular and binocular reading speed is equal in subjects with normal binocular vision. The length of progressive saccades and rate of regressive saccades did not change when switching to monocular reading, possibly at the expense of increased fixation duration. Fixation variability did not differ significantly between the conditions whereby it seems the increased fixation duration was driven by other factors. The agreement between faster reading eye and sighting dominance was 55 % suggesting that sighting dominance is an uncertain way of predicting a performance superior eye in readers with normal binocular status.

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Three dimensional control of binocular gaze during precise hand movements

Matteo Valsecchi & Karl R. Gegenfurtner
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Nine observers held a device terminating in a needle with 0.5 mm diameter in their right hand, and tried to hit a 1 mm hole in a plate located at approximately 200 mm viewing distance. From the instructed starting position to the target the tip of the device had to move 32 mm along the vertical, horizontal and depth axis. Binocular gaze position was measured with an EyelinkII system and simultaneously a ZEBRIS ultrasound device tracked the needle position.

Observers directed and stabilized gaze to the vertical and horizontal position of the target around 2 seconds before contact, whereas the vergence angle as well as the needle 3d position were adjusted until the contact was reached.

Microsaccades occurred with a relatively low rate (decreasing from around 0.4/s to 0.2/s during the two seconds preceding contact). Microsaccades re-centered gaze position on the target rather than shifting gaze between the target and the needle.

Overall the results indicate that in such a demanding task observers apply the same strategy when the object they control is far and when it is very near to contact: they set their gaze on the stable target point and avoid tracking the hand-held moving object.

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Binocular coordination in lexical decisions

Luz I. Leiros & Manuel J. Blanco
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It has been showed that people usually show a stable preference for one of their eyes (Porac & Cohen, 1976) and, these ocular differences (eye dominance) are normally distributed in observers with normal acuity (Valle et all, 2008). However, in eye movement research, only one eye uses to be recorded (typically, the right eye). So that, we could be losing some important information since we don't know which type of eye (dominant/non-dominat) are been recording in each and every observer. On the other hand, it's clear that integrating signals from the two eyes could help us to understand better how human observers can process environmental information. We shall record the participants' binocular eye movements during processing of words and non-words (pseudowords and symbols combinations), in a lexical decision task. This experiment will be conducted to examine the role of eye movements and the binocular coordination during linguistic decisions. Our aim is to find out the possible differences between dominant and non-dominant eye, analysing response accuracy and various ocular parameters for each eye and any written alphanumeric stimuli (words and non-words). In this way, we try to make clear the real role of dominant eye in the lexical information processing.

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Structure of Vergence Eye Movements

Igor Rabichev & Ekaterina Samsonova
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We set ourselves the task of researching the structure of vergence eye movement fragments. Vergence eye movements were registered using a "videooculograph" hardware and software system –which was designed in Saratov University. Two test subjects made divergence and convergence eye movements by shifting their gazes between two objects located at 50 cm and 150 cm from the observer. Each observer made 5 divergences and 5 convergences during each experiment. Experiments were repeated 5 times every 7th day, giving a total of 100 recordings, i.e. 50 recordings for each observer. The repeated experiments showed that each observer had vergence variations, because divergence and convergence may include drift as well as a multitude of microsaccades, or several macro- and microsaccades. Macrosaccades were always concordant in direction, but differed in amplitude. Meanwhile, microsac-cades might be in either the same or opposite direction and might differ in amplitude. In all cases there were more often differences in microsaccade drift direction and amplitude. We suppose that during drift, brain centers estimate the location of retinal projections and adjust the command for making the next macro- or microsaccade, which consequently assists in reaching the goal – fusion.

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Stereoscopic 3D film perception: More active vision but same recalled information

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Stereoscopic 3D (S3D) film is promoted by the film and TV industry as creating a richer and more enjoyable experience than 2D presentation. However, there has been very little empirical research investigating these claims. Previous experiments suggest that gaze is more exploratory in S3D film but have not looked at how S3D impacts our perception of dynamic scene content. In the present study we recorded participants' gaze with a binocular eye-tracker while they watched eight excerpts from an animated movie in S3D or 2D. Participants were instructed to remember as much information as possible. Processing of visual and verbal information was assessed through cued and free-recall memory tests. Eye movement results showed that ocular disparity had a greater variance in S3D than 2D, confirming that viewers reacted to the image disparity. Furthermore, saccade frequency and total scanpath length were significantly greater in S3D, indicating that viewers were more active and explored more of the screen. However, the memory tests revealed no differences in visual or verbal recall for the two versions suggesting a dissociation between the extra exploration and the representation of scene features in long term memory. These findings suggest that the impact of S3D may be purely affective.

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Posters

Co-registration of eye movements

Thursday, August 15, 12:00 - 13:30

Room: Stora salen (2nd floor)

Saccade-related brain potentials reflect the orientation of visuospatial attention: Insights from simultaneous eye tracking and EEG

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During covert attention, the locus of attention can be directed towards peripheral locations while central fixation is maintained. However, periods of fixation are usually accompanied by microsaccades. These small involuntary gaze shifts alter the retinal input and generate brain responses throughout the visual system, detectable in the EEG as a saccade-related potential (SRP). The SRP is characterized by components (P1 and N1) resembling those of traditional visual evoked potentials (VEPs). While VEPs were shown to be gain-modulated by attention, attention effects on SRPs are unknown. Here, we tested the hypothesis that SRPs resulting from the microsaccade-generated refresh of visual cortex are also selectively enhanced at currently attended locations of the visual field. In a spatial cuing task with endogenous cues we coregistered eye movements and EEG. Replicating behavioral studies, microsaccade direction after cue onset was slightly biased towards the cued hemifield. Crucially, P1 and N1 of the SRP were larger at scalp sites contralateral to the attended location. This effect persisted throughout the cue-target interval and presumably reflects a sustained gain-modulation process. In conclusion, microsaccades do not only produce artifacts in the EEG, but they frequently elicit sizeable brain potentials, which can serve as non-intrusive neural probes of attentional states.

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Impact of eye-movements and parafoveal preview on EEG correlates of word recognition: A comparison between natural reading and RSVP

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Visual word recognition (VWR) naturally takes place under reading conditions that involve eye movements and parafoveal preprocessing of the upcoming word. Event-related potential (ERP) studies have usually neglected both aspects when studying VWR with serial visual presentation (SVP). Recently, it was suggested that preview can be studied by presenting parafoveal flanker words during SVP. An alternative method is to let participants read naturally and time-lock the EEG to the onsets of fixations, yielding fixation-related potentials (FRPs). This study combined eye tracking and EEG to compare both approaches. Participants read lists of nouns of varying lexical frequency. In FRP blocks, lists were read naturally from left to right. In ERP blocks, subjects maintained fixation while lists moved word-by-word through foveal vision at a reading speed closely matching the FRP condition. In both paradigms, parafoveal words were either visible or masked with x-letters. Classic effects of word frequency were replicated across conditions. Importantly, the availability of correct previews strongly modulated the waveshapes of both ERPs and FRPs. However, these preview effects were substantially larger in natural reading, presumably because attention is shifted to upcoming words during saccade preparation. Results underline the importance of considering saccades and preview in electrophysiological VWR research.

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Testing theories of irony processing using eye-tracking and ERPs

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Irony is a common communicative tool, however, little is known about how people process and understand ironic utterances. There are a number of theories of irony comprehension, including; the Standard Pragmatic View, the Direct Access View, and the Graded Salience Hypothesis. A limited amount of empirical work has tested these theories, and to date, most studies have simply compared processing of ironic vs. non-ironic statements. A key aspect of the graded salience hypothesis distinguishing it from other accounts is that it predicts differences between processing of familiar and unfamiliar ironies. Specifically, if an ironic utterance is familiar (e.g., "That's just great!"), then the ironic interpretation should be available without the need for extra inferential processes, whereas if an ironic utterance is unfamiliar, the literal interpretation would be computed first, and a mismatch with context would lead to a re-interpretation of the statement as being ironic. We recorded participants' eye movements while they were reading (Experiment 1), and electrical brain activity while they were listening to (Experiment 2), familiar and unfamiliar ironies, compared to non-ironic controls. Results showed more disruption to eye movements during reading, and an N400-like effect for unfamiliar ironies only, supporting the predictions of the graded salience hypothesis.

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Advancing fixation-related fMRI for studies on the neural correlates of natural reading

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Studies investigating the neuronal correlates of visual word recognition usually presented isolated words which is quite remote from natural reading. The present study follows-up on a recent study from our lab in which we administered fixation-related fMRI. In this former study we analyzed brain activity in relation to the first fixation on stimulus strings and could reliably distinguish the BOLD signal in response to words and pseudowords versus unfamiliar Hebrew strings and line strings. The study, however, presented the stimuli in a circular array similar to the study which first-time reported fixation-related fMRI analyses (with faces versus objects as stimuli; Marsman et al., 2012). The circular presentation of letter strings is still quite remote from natural reading and, critically, the strings were spatially far apart which prevented parafoveal preprocessing. The present study presented lists which consisted of words and pseudowords. Critically, the lists were presented sentence-like, that is, in a single line and thus permitted parafoveal preprocessing. The ongoing study's aim is to further assess the challenges and to advance the feasibility of fixation-related fMRI and, thus, is a next step towards neuroimaging studies on truly natural reading.

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Co-registration of eye movements and brain potentials as a tool for research on reading and language comprehension

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Recent research demonstrated the feasibility of analyzing fixation-related brain potentials (FRPs) recorded during natural reading (Kretzschmar et al., 2009; Dimigen et al., 2011). Two questions arise from these studies: (1) Are effects observed with fixation-triggered EEG signals comparable to those observed in standard RSVP designs? (2) Does the combined analysis of EEG and fixation data provide additional insights into reading and comprehension processes that are not available with either method alone? Both above-mentioned studies used material known to robustly elicit strong N400 effects. The present study (N=50) examined responses to a more subtle manipulation representative of common experimental designs: we manipulated the distance between anaphoric expressions (pronouns, verb ellipsis) and their antecedents. Differences were examined using a non-parametric Monte Carlo test (Maris & Oostenveld, 2007). Increased distance of the antecedent elicited an early frontocentral negativity in response to verb ellipses (88ms-134ms, $p<0.001$) and a negativity at frontocentral and parietal electrodes on the words following pronouns (98ms-186ms, $p<0.001$). We discuss these results in the context of earlier findings and argue that adopting FRP-methodology requires factoring in complex visuomotor contingencies that are not yet fully understood and that evoke ERP effects different from those seen in RSVP designs.

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Detecting and characterising microsaccades during MEG recordings using video eye tracking and radial electrooculography

Kacper Wieczorek, Petroc Sumner & Kris Singh
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Investigating cortical activity related to microsaccades can provide insights into how the brain combines sensory and oculomotor signals to produce stable perception. MEG provides excellent temporal resolution and is less susceptible to muscle artefacts than EEG, allowing spectral characterisation up to the high gamma band.

We used a MEG-compatible, remote video eye tracker and seven REOG electrodes to detect microsaccades and characterise their parameters when participants fixated in MEG suite. We recorded eye tracker in pupil-only mode in order to achieve higher precision while participant's head was immobilized inside the MEG dewar with a head cuff and chin rest. Movement artefacts in eye tracking data were controlled for by checking each detected microsaccade with REOG saccadic spike potential and by checking the video recordings of the eye image. With this setup we could detect microsaccades that had parameters comparable to those found in less challenging environments.

We demonstrate how microsaccade detection during MEG recordings can help to disentangle cortical signals originating from displacement of the receptive fields over a visual stimulus from motor signals communicating microsaccade execution. Moreover, we show that individual variability in microsaccadic rate and amplitude can be related to individual differences in cortical activity.

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Looking for a face in the crowd: fixation-related potentials in natural viewing

Lisandro Kaunitz, Juan Kamenikowski, Alexander Varatharajah, Mariano Sigman, Rodrigo Quiroga & Matias Ison
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Despite the compelling contribution of the study of event related potentials (ERPs) and eye movements to cognitive neuroscience, these two approaches have largely evolved independently. In particular, EEG recordings typically involve flashing stimuli at fixation to avoid the large artifacts that eye movements introduce in the ERPs. We designed a free-viewing visual search paradigm that allowed us to concurrently record EEG and eye movements while subjects were asked to find a hidden target face in a crowded scene with distractor faces. Fixation-related potentials (fERPs) to target and distractor stimuli showed the emergence of robust sensory components associated with the perception of stimuli and cognitive components associated with the detection of target faces. We compared those components with the ones obtained in a control task at fixation. By using single trial analyses, fixations to target and distractors could be decoded from the EEG signals during free-viewing. Our results contribute towards a better understanding of the mechanisms of target detection during naturalistic visual search.

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Posters

Gaze Interaction & User Modelling

Thursday, August 15, 12:00 - 13:30

Room: Stora salen (2nd floor)

Antagonists for Visuo-Spatial Games

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We report on results of a project in which fixation and scanpath data of a human player is used to adapt the live play of a computer-based antagonist in the strategy game 'Hex'. Specifically, eye movement data informs algorithms that adapt the strength and behaviour of an artificial intelligence (AI) game engine, which drives the opponent's play. Our antagonistic player considers scanpaths and fixations in areas of interest of 'Hex' game cell groups to establish the player's current strategies. It uses data on frequency with which the human player changes the focus of her interest in order to predict the level of confidence which she currently has in her play, and it modulates its own strength accordingly. Contrary to the common use of AIs in digital games for optimising computer-based players, our approach aims at creating computer-based players that satisfice – similar to what can be observed in human players, especially in novices. We assume satisficing play of computer-based opponents to be a key aspect in creating a more engaging and interesting experience for humans in playing digital games.

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Roll of eye dominance in Eye - Gaze input cursor control with variable load target tracking

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In closed loop eye-target tracking tasks (eye-gaze input), the feedback cursor could be coupled to the dominant eye, the non-dominant eye or to the mid-binocular location. We study the effects of eye-cursor coupling method on measures of tracking efficiency in variable-load scenes. Participants performed 2D tracking tasks composed of 3 dynamic target profiles (straight lines, curved lines, and straight lines with target disappearances), with 4 constant-velocity levels, and a compensatory-tracking secondary task.

Participants were tested for sighting dominance (Dolman's test) and dominance level (Parallel Testing Infinity Balance PTIB).

Ocular Dominance (OD) theory proposes the sighting-dominant eye as reference point for visual direction. Accordingly, optimal performance is expected with dominant-eye coupling. In contrast, the "Cyclopean eye theory" proposes the average-binocular location (Egocenter) as reference point for visual direction. Accordingly, optimal performance is expected with binocular coupling.

Our results indicate an advantage for the Ocular Dominance theory (OD) with balanced-dominant participants. This advantage altered consequently to emphasized dominance levels and task conditions (Profile/difficulty).

We suggest a binocular coupling optimization model of differential weight adjustment, according to dominance level and tracking task characteristics.

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EyeTick - Towards a fully functional gaze-controlled ticket vending machine

Stefan Ruff, Peter Brandstädter, Florian Hoppe, Juliane Bock & Antje Venjakob
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EyeTick aims at developing a gaze-controlled ticket vending machine which allows the hands-free execution of all necessary actions. The project is realized using a mobile remote eye tracker that is well suited for the use in such contexts. The initial idea behind the project is that innovative interaction techniques already applied to domains like gaming will not stop at technology installed in public space. In the project an integrated approach is followed. It includes the evaluation of human characteristics and those of the interface-eye tracker unit to facilitate access for a maximum number of users. This comprises the exact positioning of the system to suit anthropometric aspects as well as a user-friendly calibration procedure. To implement robust and efficient gaze interaction, different input modalities are compared. These modalities are dwell time, blinks and the recognition of specific gaze patterns to select buttons. In a first step the modalities are compared employing a conventional, touch optimized interface design. To further eliminate input errors, the modalities are then tested with three different types of interfaces. Each interface is designed to optimally suit one of the three input modalities.

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Previewable scrolling by gaze

Oleg Špakov
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Browsing long documents and web-pages in gaze-controlled interfaces is a challenging task for users: the existing methods suppose to keep looking at the dedicated page areas or buttons to scroll it. This approach does not allow inspecting directly the amount scrolled, and users have to rely on their peripheral vision. We propose using thumbnails placed into these areas. Our solution implies two transparent panels superimposing the top and bottom of a web-page displayed in a browser, so that each panel is equally divided into 4 areas designated by a semitransparent icon. Each area corresponds to one of the scrolling modes: slow, medium, fast (all for smooth scrolling), and scrolling by page. When a user glances at any area, a thumbnail of the visible part of the page fades in. After a dwell time the page starts scrolling according to the chosen mode, and the view in thumbnail refreshes in real time. We hypothesize that the combination of in-place preview of the scrolling result combined with scrolling modes brings more efficient and convenient interaction in gaze-controlled interfaces. We will conduct a study to test and compare the proposal against the existing solutions in terms of task completion times and subjective ratings.

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Optimizing visual search in multi-screen monitoring

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Monitoring multiple screens can be challenging for an operator who has to constantly switch his attention between different screens looking out for operationally relevant information and neglecting irrelevant ones. The difficulty of this task increases when interruptions and distractions occurs making visual scanning patterns very subjective and unpredictable leading to lower target detection rates. This study introduces a new concept Asynchronous Automated Vision System (AAVS) which aims to improve detection performance in monitoring multiple screens. This AAVS concept involves the integration of an asynchronous interface with eye tracking technology, coupled with visual scanning guidelines to allow more efficient scanning. A low fidelity prototype has been built and a pilot study involving 5 subject matter experts has been conducted to evaluate the feasibility and effectiveness of such an integrated system. Preliminary results indicate an improved target detection rate across all subjects. Design recommendations and feedback were also collected to further enhance future versions of this concept.

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Image Region Labeling by Gaze Information during Image Search and Image Tagging

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Tagged image regions are a valuable meta information which can support users in various activities such as image search. In our previous work, we have shown that it is possible to annotate image regions by means of gaze information in a controlled experiment with given tags. Tagging of regions on the fly, while the user is annotating images or is searching for images is subject to this experiment. It consists of three parts: tagging oral, tagging written, and search. The experiment application is inspired by standard tagging and search pages as found online and used by millions of users. The tagging is either done by speaking the tag into a microphone or by typing it. In the search, the user is asked to find a photo satisfying a given task (e.g., "search for a red car"). The goal is to link the tags respectively search queries to image regions obtained from automatic image segmentation.

24 subjects have participated in the experiment. The images are taken from data sets offering ground truth region annotations. Therefore, we are able to evaluate our approach by comparing the gaze-based annotations to this ground truth data. First analysis results will be presented at the conference.

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Gaze-reactive tags on images

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We implemented a photo album application with an image tag feature that was operated with the gaze: the tag was automatically activated when the user fixated at the tagged object. We conducted an experiment to compare the usability and usefulness of the gaze interface to two alternative designs. The first alternative used the mouse to activate the tag feature. The second alternative had no image tag feature. Data were gathered from ten participants. The results are based on log files, a memory quiz about the content of the photo albums, and a questionnaire. The log files show that when working with gaze activated tags the participants' gaze fixated more on the photo and less on the caption text. Results from the questionnaire show that the gaze interface was rather pleasant and easy to use. Still, most participants had suggestions for improvement of the interface to help in finding tagged objects on the image. Most participants were willing to use a gaze controlled tag function on web applications but only if they could control when the application tracks their gaze. The results from memory quiz indicate that the gaze interface helped in memorizing the objects in the photo.

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Interactive Aids Benefit Learning by Drawing Gaze to Text

Krzysztof Krejtz[1,3], Andrew Duchowski[2], Agata Kopacz[1], Piotr Chrząstowski-Wachtel[4] & Izabela Krejtz[3]
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The paper examines the role and efficacy of interactive multimedia learning materials. Animated multimedia often lowers learning effectiveness by overloading student's cognitive resources. According to Cognitive Load Theory and self-regulation frameworks, authors hypothesized that interactive applets will enhance learning by promoting regulatory mechanisms of attention allocation. In the present study (N = 63), interaction is compared to dynamic animation and a book-style static illustration accompanying text during learning. As expected, results showed a learning benefit afforded by interaction reflected in gaze distribution assessed using eye tracking methodology. Recorded gaze revealed underlying attention mechanism. Interaction motivated careful reading of the problem description through to completion, leading to improved comprehension of the material. In line with hypotheses, students' working memory capacity appeared to be an important moderating factor. Interactive applets are cognitively demanding leading to the conclusion and as such they are most effective for high working memory individuals. The results are discussed in terms of the mechanisms of visual attention processes underlying learning "from the screen" and lead to conclusions for educational practitioners pointing at factors which may interfere with learning in interactive multimedia environments.

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Concept of Gaze Driven Map Application

Rostislav Netek
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Based on the fact that the eye-tracking device allows advanced human-computer interaction, there is great opportunity to implement it in the field of Geoinformatics and Digital Cartography. The ability to control map application on the screen by sight only has been the main aim of the pilot study. It has been developed in the first Eye tracking Lab in the Czech Republic at the Dept. Of Geoinformatics, Palacký University.

Simple digital map has been developed as the stimulus. The interactive map application contains four icons for control movement and two icons for zoom in/out. Over each icon the POI area is drawn. Each POI is associated with the specific key (four arrow keys, keys +/-) in the specialized eye-tracking software. The crucial is fact that the map is based on key-sensitive operating. If the POI area is targeted by sight, the appropriate key is activated. Finally the map changes the scale or the position according to user's requirement. The pilot study compares software presumptions of both commercial SMI and open-source OGAMA. Gaze driven map application rejects limits associated with locomotive control. This approach could be utilized for example by handicapped persons or in the field of vehicle navigations.

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Using gaze data to evaluate post-editing strategies and machine translation quality

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Technological development and globalization continue to increase the need for translations. In order to improve efficiency and cost-effectiveness, professional translators increasingly make use of machine translation (MT) output, especially in the field of software localization and technical documentation, to edit it and create a fluent text that adheres to the given text conventions. This procedure is known as post-editing (PE).

In a series of experiments in the context of the CASMACAT project (http://www.casmacat.eu/), 24 translators (half professional, half semi-professional) produced translations from scratch vs. PE tasks. Different methods were used to track back the different (un)conscious cognitive processes and strategies involved in the different tasks: keylogging (Translog II), eyetracking (Tobii TX300) and interviews.

The focus of this talk will be on the evaluation of the translators' gaze behavior in order to empirically answer the following questions: First, do translators develop certain reading strategies when working with the MT output and which role does increasing expertise play? How can these strategies be used for translators' education and training? And secondly, is there a correlation between gaze behavior and MT quality? How can these findings be used to improve MT systems?

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Visual feedback delay decreases the usability of our own body

Seiya Kamiya & Takako Yoshida
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The temporal delay between human action and its visual feedback is critical for self-body sensation and for human–machine interactions. We tested how visual feedback delay changes two types of self-body sensations: sense of agency and ownership for the hand shown on a visual display, and for the image on the visual display as first person field of view or some sort of self-vision-ness. By observing a delayed video image on a CRT monitor, the participants executed the block-copying task that required manually picking up and placing coloured blocks to duplicate the block pattern. A questionnaire survey showed that as the feedback delay increased, the participants' sense of ownership and agency decreased both for their hand in the display and the video image itself. These questionnaire data and the distribution of fixation duration showed qualitative changes before and after a 317-ms delay, suggesting that participants changed their behaviours at around 317 ms. Whether this change was due to the visual and tactile feedback asynchrony remains unclear, because only the visual feedback was delayed. However, our results suggest that the 317-ms visual feedback delay is critical in changing a self-body sensation to an other-body sensation.

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Cardinal: Typing with Low-Specificity Eye Gestures and Velocity Detection

Alexandra Haagaard, Alan Boulton, Nell Chitty & Geoffrey Shea
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Current assistive and augmentative communication (AAC) strategies for persons with severe motor impairment often utilize gaze fixation-based input. However, this strategy limits the user's ability to make and maintain eye contact in conversation. Given the importance of eye contact in the modulation of interpersonal interactions, this could present a substantial problem. This project seeks to develop a concept for a minimally motor-dependent AAC technology that better accommodates eye contact during conversation. We have determined that this concept should make use of already-established AAC paradigms, in order to maximize ease-of-learning for users and conversation partners. We are also seeking to optimize how the concept will address several key concerns of AAC users: 1) size and flexibility of vocabulary; 2) speed and comfort of communication. We are exploring a combination of eyetracking technology with an E-Tran frame-type approach that allows users to select letters through sequences of Cartesian eye gestures, which can be memorized and executed easily. This would eliminate the screen used in conventional gaze-based systems, thus removing a barrier between conversants and allowing for better eye contact.

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EyeK: An Efficient Dwell-Free Eye Gaze-Based Text Entry System

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Over the last three decades, eye gaze has become an important modality of text entry in large and small display digital devices covering people with disabilities beside the able-bodied. Despite of many tools being developed, issues like minimizing dwell time, visual search time and interface area, eye-controlled mouse movement stability etc. are still points of concern in making any gaze typing interface more user friendly, accurate and robust. In this paper, we propose a gaze-based text entry system, EyeK, which optimizes the constituent virtual keyboard layout with respect to eye gaze movement as well as diminishes dwell time, mitigates mouse movement time and corrects spelling errors while typing with gaze. Performance evaluation shows that proposed interface achieves on an average 11% higher text entry rate and 7% less error rate over the existing interfaces. As designed, the proposed interface can effortlessly be suited in small display devices like Mobile phone, PDA etc. Also, the experiments can easily be replicated for motor disabled people.

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Posters

Measurement & Analysis

Thursday, August 15, 12:00 - 13:30

Room: Athen (ground floor)

Using spatial point processes to evaluate models of eye guidance in scene viewing

Ralf Engbert[1], Hans A. Trukenbrod[2] & Felix A. Wichmann[3]
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The distribution of fixation locations on a stationary visual scene can be interpreted as an intensity function of an underlying spatial point process (Illian et al., 2008). In point process theory, we try to analyze the point-to-point interactions to infer possible generating mechanisms. The pair correlation function provides a mathematical measure of the density and statistical interaction of neighboring points. We explore the possibility to apply the pair correlation function in the spatial statistics of fixation locations generated from individual scanpaths of human observers. We demonstrate that the inhomogeneous pair correlation function removes first-order heterogeneity induced by systematic variation of saliency within a given scene from second-order spatial statistics. Results indicate significant spatial clustering at short length scales. Finally, we use the inhomogeneous pair correlation function for the evaluation of a dynamical model of saccade generation in active vision during scene perception.

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An integrated data structure and procedure for statistical analysis of eye movement data

John Jr-Hung Lin & Sunny S. J. Lin
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An integrated data structure combing off-line and on-line eye data and a statistical analysis process were proposed. The data structure combines off-line measure, which is two-dimensional arranged, and on-line eye movement data which is hierarchically arranged. To analyze data collected by eye-tracker, off-line and on-line data need to be merged first. Then relationships between on-line and off-line data are investigated. To avoid complicated repeated statistical analysis, resulting from eye behavior indicators (e.g., fixation, saccade and other indicators developed based on them), the researcher developed new procedure of SAS that is capable of processing experiment with off-line and on-line data. Three stages are as below. First, in the pre-process stage, data were merged and reconstructed. Next, during the process stage, multiple statistical analyses are executed based on experimental design. Then the report-generating stage, needed results will be automatically saved and exported in *.doc and *.pdf (accompany with bookmark) format. Meanwhile, generalized datasets during the procedure can be used for further analyzed. Most importantly, intuitive configuration and well-defined structure eliminate the redundancy of the eye movement study; the procedure and the interface of this analysis become user-friendly and time-saving. Moreover, users can add modules they prefer to enhance the functions.

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Predicted perception of image sharpness using attention modeling with top-down pathways on semantic region features

Michael Schwarz, Stefanie Wechtitsch, Albert Hofmann, Werner Bailer, Georg Thallinger, Gerald Fritz & Lucas Paletta
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Automated visual quality analysis becomes an increasingly relevant aspect in efficient media production (Fassold et al., 2012, Proc. IEEE Intl. Symp. Multimedia). Quantitative measures of sharpness are used by broadcasters to identify important media characteristics such as the potential for resolution upscale. Computational models estimate the perceived sharpness to enable predictions of human response in massively automated media analyses. Comparison of fixations on different resolution imagery (Judd et al., 2010, J. of Vision) implies that consistency between lower and higher-resolution fixations depends on image content and complexity. We investigated the impact of image complexity and content, with 14 persons of 25-65 years, using eye-tracking to report locations of perceived sharpness in videos with various resolutions. Mean opinion scores (MOS) were used to validate the sharpness (Ferzli et al., 2007, Proc. ICIP). We applied automated semantic video block and feature (texture, motion, faces, persons, etc.) segmentation and used the resulting regions of interest to parameterize top-down pathways of the computational attention model of (Judd et al., 2009, Proc. ICCV). This innovative model provided superior saliency detection on the video sequences and allowed relating the sharpness perception reported by the viewers to specific regions, thus increasing the reliability of the sharpness scores.

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When bigger is not better: Modelling distractor disruption in a neural field model of the superior colliculus

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Saccade end-points are attracted toward distractor stimuli that are spatially and temporally close to the saccade target. The magnitude of this effect shows a reversal pattern with distractor size (Tandonnet et al. 2012): for relatively small distractors attraction increases with size, but after a critical point attraction decreases with size. To explain this, it was suggested that lateral connections in the superior colliculus lead to auto-inhibition of large distractors. Here we modelled the superior colliculus with a 2D map of spiking neurons with a 'Mexican-hat' lateral connection profile. First, we show that auto-inhibition occurs for intermediate stimulus sizes, while larger stimuli maintain strong activation at their extremities. Second, we simulate the experiment of Tandonnet et al. and successfully reproduce the reversal pattern in the behavioural data, but only if the Mexican-hat is elliptical, not circular as normally assumed (whereas a Gaussian connection profile provides a less strong reversal pattern). Importantly, however, the reversal pattern has two origins in the model: auto-inhibition, as suggested, and a repulsion effect stemming from the active extremities of the distractor. Testing the existence of this repulsion effect behaviorally provides a novel avenue for testing the Mexican-hat hypothesis in humans.

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Evaluation of the usability of the two prosaccadic pradigms in the monitoring of central nervous system development and aging

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Evaluation of the statistical parameters of saccadic latency distribution are potentially useful to monitoring of the functional status of the central nervous system. We decided to evaluate the usability of the rapid target walk paradigm (RTW) for monitoring of the development and aging of the central nervous system by comparing it with the standard prosaccade paradigm. RTW allows to shorten the duration of saccadic latency examination what is critical for providing the constant level of sustained vigilance during the collection of large number of saccadic responses, which are required for distributional analysis of saccadic latency (Witkowska & Ober, 2012). We examined 21 older subjects , 24 young adults and 16 children. The results of the RTW showed significantly differences of the median latencies between all three groups. For the standard task we found differences between older adults and two other groups (children and young adults do not significantly differed). We tried to classify subjects to the particular age group basing on individual results (median latency). For the standard paradigm the classification tree assigned incorrectly 23 the subjects out of 61 cases. Result of the RTW reduced the incorrect classification to only 12 out of 61 subjects.

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A unified model of eye movements implemented and validated on a robotic platform

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In this work we propose the integration of three controllers which realize the most basic oculomotor behaviors. In particular, the proposed system is composed of a controller for the vestibulo-ocular and optokinetic reflex (VOR-OKR) for gaze stabilization (Schibata et al., 2001, Franchi et al. 2011) based on a feedback error learning, a smooth pursuit controller based on prediction and online learning of the target dynamics with a catch-up saccade system for tracking moving objects (Zambrano et al., 2010; Falotico et al., 2010), and saccades for selecting visual attention (Maini et al., 2008). Each of these behaviors has been derived from neuroscientific inspirations. Shifts between the three subsystems have been managed through mechanisms of inhibition or cancellation depending on the perceived stimuli. To assess the performance and validate the proposed system, this unified model has been implemented on the iCub robotic platform. The experimental tests have been carried out on specific tasks derived from the neuroscientific literature (de Brouwer et al., 2002; Guitton et al.,1992; Cullen et al., 2004) and involving shift between subsystems. The comparison with human data, abstract from literature, shows the effectiveness of the proposed approach.

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Shannon's channel capacity versus throughput based on Fitt's index of difficulty: application to oculomotor system

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Common practice evaluating informational characteristics of movement control system is application of Fitts law. Throughput values of gaze pointing obtained in this study while using Fitts index of difficulty are no way comparable to the throughput of manual pointing, therefore entropy based method for evaluation of information processing capabilities of the oculomotor system is considered. Target acquisition task is seen as information transfer process. If information rate of the source (frequency of discrete stimulus presentation) increase, at some point oculomotor system will not be able to track stimulus correctly and position error i.e. lost information during transfer will increase. This lets formulate that human oculomotor system has a limited channel information capacity, which can be used as important characteristic to determinate control system of the eye movements. Results show that while frequency of stimulus presentation 1/T increase, information transfer rate over an oculomotor channel increase also until reaches its maximum of 12.92 bit/s at T=0.3s. This maximum could be described as a channel capacity of the oculomotor system, which also seems to depend on the distance and width of the stimulus. With slight modifications proposed method is applicable for evaluation of channel capacity of smooth pursuit subsystem.

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Automatic analysis of in-the-wild mobile eye-tracking experiments using object detection and recognition

Stijn De Beugher, Geert Brône & Toon Goedemé
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In this paper, we present a novel method for the automatic analysis of mobile eye-tracking data in natural environments. Mobile eye-trackers generate large amounts of data, making manual analysis very time consuming. Available solutions such as marker-based analysis minimize the manual labour but require experimental control, making real-life experiments practically unfeasible. We present a novel method for processing data of mobile eye-trackers by applying object detection and recognition algorithms. This enables the analysis to be performed on the object level rather than the traditionally used coordinate level. We apply algorithms to detect specific objects, human bodies and faces. We introduce our system and give an overview of possible applications in a variety of domains. Furthermore we present challenging real-life experiments.

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Posters

Visual Search

Thursday, August 15, 12:00 - 13:30

Room: Stora salen (2nd floor)

Statistical stability facilitates visual search

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We process a fraction of information in each glance and the retinal image changes constantly, yet we perceive the world as stable. Theories of visual stability generally posit that we anchor representations to one object as we shift our eyes. However, recent findings that observers construct perceptual summaries of the statistical regularities of sets of objects may help explain our stable percept of the world. To examine whether such perceptual summaries facilitate visual stability, we manipulated the statistical regularity of a visual scene while observers performed a search task. Specifically, we modulated the standard deviation of the sizes of an array of Gabors while observers searched for a left or right tilted target among horizontal distractors. In stable blocks, the standard deviation of the background diameters was constant for 5 to 8 displays, whereas in unstable blocks, it changed on each trial. Overall, observers were faster and made fewer saccades when correctly judging target tilt in stable versus unstable blocks, but fixated correctly judged targets longer in stable blocks. Results suggest that when background statistics remain constant, observers use these statistical regularities to build and maintain a stable context, freeing the resources needed to perform a perceptually intensive search task.

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Eye-guidance during scene search: The role color plays in central and peripheral vision

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How does the availability of color across the visual field facilitate gaze during real-world search? To answer this question, the presence of color in central or peripheral vision was manipulated using a 5° gaze-contingent window that followed participants' gaze. Accordingly, scenes were presented in full color (C), grey in central vision and colored in peripheral vision (G-C), colored in central vision and grey in peripheral vision (C-G), and in grey (G). The color conditions were crossed with a manipulation of the search cue: the search object was cued either with a word label or a picture of the target. Across color conditions, search was faster during target template guided search. Search time costs were observed in the C-G and G conditions, highlighting the importance of color in peripheral vision. In addition, a gaze-data based decomposition of search time revealed color-mediated effects on specific sub-processes of search. When color was not available in peripheral vision, it took longer to initiate search, and to locate the search object in the scene. When color was not available in central vision, however, the process of verifying the identity of the target was prolonged. In conclusion, color-information in peripheral vision facilitates saccade target selection.

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Memory processes in repeated covert and overt visual search

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Several authors have shown that participants acquire a memory when they search the same display repeatedly. Other authors have argued that memory does not guide search. We investigated whether differences between covert search (without eye movements) and overt search (with eye movements) can account for these different findings. Participants searched for a target letter in circular displays of 3, 6 or 9 items. In the repeated search condition the same display was presented for 90 consecutive searches, whereas the search display changed in the unrepeated condition after each search. There were two eccentricity conditions: In the covert search condition participants could search the display using peripheral vision. The overt search condition required eye movements to identify the search items. For set sizes 3 and 6 we confirmed earlier results that search efficiency did not benefit from repetition in covert search. Critically, we found that search efficiency increased and the distance between the first fixation and the target decreased over time in overt, but not in covert repeated search. Our results demonstrate that memory does guide repeated search if search requires eye movements. We discuss these results with respect to different resource requirements involved in overt and covert attention.

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Eye movement control by artificially learned rules: Using VowelWorld to study the development of scene guidance

Melissa Le-Hoa Vo & Jeremy M. Wolfe
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Scene guidance is difficult to control parametrically using real-world scene stimuli. For this purpose we used "VowelWorld" (VW), a paradigm that permits control of different types of guidance rules in artificial displays. We tracked observers' eye movements while they searched for either an "A" or an "O" in arrays of consonants on multicolored, 10x10 checkered backgrounds. Three sources of guidance were available, but not made explicit: (1) Background colors provided "color guidance", e.g., "A" was more likely to be in a red part of the display, an "O" in a yellow part. (2) Chains of circles provided "structural guidance" in that vowels lay either on or next to a circle similar to objects resting on surfaces and not floating in mid air. (3) Letter gradients provided "semantic guidance" in that an "O" would be near Ns & Ps like a knife is near a fork. Over the course of 300 trials, participants learned to restrict search space by about 20%. Already after 50 trials, initial fixations were increasingly color guided, while structural guidance took longer to evolve. We will compare these results to gaze guidance of participants with full or gradually introduced knowledge of all VW rules.

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Predicting object identity across eye movements: Evidence from visual search and object recognition

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This study investigates whether peripheral and foveal representations of an object become associated across saccades and how such associations are used for visual search and object recognition. In an acquisition phase participants made saccades to peripheral objects. For one object, features did not change across saccade, so that one and the same object was presented to the peripheral and central retina (normal exposure). For another object, we consistently changed a feature in mid-saccade, so that slightly different objects were presented to the peripheral and central retina (swapped exposure). Transsaccadic learning was assessed in two different test phases. In Experiment 1, participants made eye movements to peripheral objects and were asked to choose a foveal test object matching the peripheral object (object recognition). In Experiment 2, we briefly presented a target object in the fovea and asked participants to search this object in the periphery (visual search). Both experiments revealed better performance for acquisition congruent combinations of peripheral and foveal objects as compared to acquisition incongruent combinations. This suggests that transsaccadic associations are utilized to predict how peripheral objects might appear in the fovea (relevant to object recognition) and how sought-after objects might appear in the periphery (relevant to visual search).

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Visual search retention is preserved across the lifespan

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Active vision is thought to involve two concurrent processes: A prospective process for selecting the next saccade goal, and a retrospective process for retaining previously fixated items. We previously reported how visual working memory (VWM) capacity predicts refixation probability during visual search, suggesting that the retention process is mediated by VWM. VWM is known to decline with age but it remains unclear whether there is a concomitant decline in search retention. We tested the hypothesis that search retention declines with declining VWM over the lifespan by comparing the performance of younger and middle-aged adults in both a visual search and a change detection task. VWM capacity was significantly lower in middle-aged as compared to younger adults. Middle-aged adults had longer search times, owing mostly to longer fixation durations, than younger adults. The average number of fixations and the probability of refixation during search, however, did not differ between age groups. These data suggest that while VWM declines with age, visual search retention remains intact. Taken together with previous findings of a narrowed attentional window and greater representation for distracters with age, our results suggest that compensatory mechanisms exist for preserving visual search efficiency across the lifespan.

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Training saccadic eye movements using visual search task.

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Systematic training of saccades and fixations, using the visual search paradigm, serve as primary help for patients, who have problems with reading control, or have central vision loss and are forced to read using peripheral retina. For this purpose, we are developing a method to train the saccadic eye movements and fixations using a type of visual search task and taking into account the contribution of peripheral visual information. An individual has to find specific letters in the visual search task, where is provided the different kind of peripheral visual information – distractors differ with colour and/or thickness. Moreover, the reading task is used to compare the parameters of eye movements with the ones developed in visual search task. Analysis of the first data reveals that peripheral visual perception significantly affects the spatial parameters of saccadic eye movements, but not the temporal ones ($p<0.05$). Compared to reading, the parameters of eye movements and fixations are similar to the ones in our developed visual search task. The data is to be used in development of method to train the saccadic eye movements and fixations during reading.

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Visual working memory modulates saccades during visual search

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When multiple stimuli appear simultaneously in the visual field, they are not processed independently, but rather interact in a mutually suppressive way and compete for neuronal representation. Is visual information automatically placed in visual memory during each saccade, or can we control which information is retained and which is excluded? The purpose of this study was to examine whether saccadic are top-down modulated by visual working memory utilizing a modified pre-cueing paradigm. Participants had to identify a tilted line amongst vertical distractors in valid, invalid and neutral cues conditions. Each line was surrounded by a shape(geometric figureVS abstract shapes) that could be precued by an item held in memory.

The results showed that cuing affected the RTs and the first saccade in search. The saccadic latency decreased in valid condition. Conversely interference occurred resulting in an increase of saccadic latency in invalid condition. Cue validity influenced saccadic latency in a very similar pattern between abstract shapes and geometric figure. Shorter saccade latencies were found in geometric figure than abstract shapes. The results show that visual working memory contents modulates saccadic during visual search, suggesting that it is a general phenomenon.

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How does Visual Search Behaviour Adapt when Paired with An Inefficient or Inaccurate Partner?

Charlotte A. Riggs, Hayward J. Godwin, Simon P. Liversedge & Nick Donnelly
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Numerous real-world tasks involve observers searching in pairs or teams. Often this approach is adopted under the assumption that a division of labour can increase the chances of accurately detecting targets (for example, each member of a paired team searches for a different target). However, one issue that has not yet been explored is the extent to which search behaviour adapts or shifts when a partner in a pair shows signs of poor or inaccurate search. In this poster we will report data from an experiment that is currently underway. Participants searched for a given target under the pretence that a partner had already searched the displays for a second target. Each target was presented on 25% of trials (i.e., overall, the targets were together presented on 50% of trials). We manipulated the efficacy of the (non-existent) partner's search behaviour, with feedback given in relation to whether the partner was correct or incorrect in their responses for each trial. We will discuss our results in relation to the hypothesis that participants will 'step in' and begin to search for the (non-existent) partner's target once it becomes clear that the partner shows evidence of being poor at detecting their target.

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How do "hypertext preferrers" differ from "non-hypertext preferrers" in their reading and link-selection strategies in hypertext?

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Based on a claim made by Carr (2010) we examined whether the inclusion of hyperlinks (per se) in an encyclopedic Wikipedia-like text (i.e., a hypertext) impaired readers' text comprehension as compared to an equivalent version with bold words instead of hyperlinks. Fifty-six students were asked to read two expository texts: one hypertext that included 30 hyperlinks and a non-hypertext containing bold words instead of hyperlinks, with the topics of the two texts being balanced across participants and text formats. Text comprehension was measured by a set of inference-questions after having read each text. Results showed that only a subgroup of 13 participants, who indicated to generally prefer non-hypertext over hypertext formats (i.e., non-hypertext preferrers), had significantly lower text-comprehension scores in the hypertext than in the non-hypertext. Text comprehension of the other 43 participants, who indicated to generally prefer hypertext over non-hypertext formats (i.e., hypertext preferrers), however, did not differ significantly between text formats. Based on eyetracking-data we will analyze whether and how the reading and link-selection strategies of the non-hypertext preferrers differed from those of hypertext preferrers, which might have resulted in the decreased comprehension of the former when having read the hypertext. Results will be presented at the conference.

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The Eyes – Captured by Surprise

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We investigated the influence of a surprising color swap on reaction times (RTs) and eye fixations. Within a visual search task participants reported the location of a shape-defined target letter above or below a distractor letter. To establish an expectancy regarding target colors, fixed colors were first assigned to both, target shapes (e.g., red) and distractor shapes (e.g., green). To elicit surprise, this expectation was next violated by an unannounced swapping of target- and distractor-associated colors in the surprising trial. In addition, later color swaps were used to estimate costs of better anticipated and less surprising changes. We found longer RTs in surprising trials compared to consecutive trials without color swaps and to better anticipated swaps (Experiment 1). The distractor letter was fixated longer during and immediately after the surprising trial compared to trials before the color swap (Experiment 2). By varying the number of distractors per trial, we aim to clarify search-time differences between trials before and after the surprising trial: Whereas uninstructed color search during the pre-surprising trials should result in a flat search slope for the different set sizes, form search should show a steeper slope depending on the number of distractors in each display (Experiment 3).

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Evidence from different paradigms for top-down contingent capture in colour-variegated stimuli

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In the past, highly-controlled visual search and cueing paradigms used monochromatic stimuli to confirm top-down contingent capture of attention by colour (e.g. Folk & Remington, 1998). These studies lack one critical aspect of everyday colour search: colour variegation. This could be crucial because colour-variegated targets cover a larger colour spectrum and thus exhibit potentially more overlap with irrelevant colour distractors. In addition, top-down search settings for colour-variegated stimuli could be more demanding. As a consequence, top-down contingent capture could be restricted to artificial monochromatic stimuli. To study colour capture under more natural conditions, we used photographs of real fruits/vegetables as colour-variegated stimuli. Results of a series of visual search tasks demonstrated that top-down contingent capture extends to colour-variegated stimuli. This was additionally confirmed using a cueing paradigm. In a current series of studies we are investigating the same phenomenon in a saccade reaction time task in order to find a reflection of the behavioural results in eye movements (saccade latencies, saccade trajectories).

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Hand versus eye: How inhibition of return in visual search is dependent on the type of response

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Previous research on inhibition of return (IOR) has demonstrated that items which were recently inspected during a visual search are inhibited even if that search was completed. In contrast to these findings, we have shown that IOR is no longer functioning once a search is finished. However, we measured IOR via saccadic responses whereas previous studies typically focused on manual responses. Hence, it is possible that the different types of responses produced the inconclusive findings regarding the occurrence of IOR after a search. To investigate this question, we had participants search through different letter displays while their eye movements were monitored. Immediately after the end of each search we probed an item which had been previously inspected during search or not. On half of the trials, participants were instructed to saccade to this probe whereas on the other half they had to press a button as soon as the probe appeared. Results showed IOR (i.e., increased response times to already inspected items compared to non-inspected items) in terms of manual responses but not in terms of saccadic responses. This suggests that the relationship between the saccadic system and more general attentional processes is not as close as previously thought.

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Visual Search: Ignoring targets by colour

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It is well known that visual search can be improved if the target's colour is known. But if one only knows of what colour the target won't be, will this also have an effect on visual search? We hypothesized that this information is less beneficial, as suggested by a study of real-world search performed by colour blinds (Kugler et al., ECEM 2011).

We used a classical array search paradigm with the target being present or absent. Each search array consisted of coloured target and distractor disks, each with a vertical black line inside the disk. The target in a search array was characterized by a small discontinuation of the vertical line.

Participants were either told the colour of the target (valid colour), or a colour the target would not be (excluded colour). In both cases, half of the disks were of the given colour.

Results show that search in the excluded colour condition takes significantly longer (ANOVA, p=1.9*10-17). The slope of search time vs. number of items is 46% higher (corresponding to 70 ms per item, target absent trials). We conclude that excluding objects by colour in search is not as efficient as positively selecting possible targets.

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"Searching" versus "Browsing"-Influence of processing mode on attentional capture

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User's cognitive processing modes influence the advertisement effectiveness on Web ads. This research investigates the difference between "Searching" and "Browsing" conditions. These two conditions' underlying mechanisms could be related to "feature search mode (FSM)" and "singleton detection mode (SDM)". The study hypothesizes that users under FSM would have better eye-movement and recognition results on the ads relevant to the target in mind than under SDM. However, there is no specific goal under SDM, so salient ads will attract more attention. Besides, the study create the external relevance, named "dispaywide appearance" to fully explain the "relevant" concept. The stimuli were manipulated in the form when subjects mouse over any vision-focused object, the object and advertisement will be surrounded by 5-pixel and red rectangles simultaneously. The laboratory eye-tracking experiments and follow-up investigations were conducted. The results indicate processing modes elicited by instructions really affect the effectiveness of relevant and salient ads. Subjects under FSM had more intention to interacting with relevant advertisement; subjects under SDM had more positive actions toward salient advertisement. The result also showed displaywide appearance had main effect across two modes. Accordingly, the study provide guidelines for clarifying the distinct behaviors on Internet and design principles for Web ads.

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Tracking the eye during attentional set shifting: an eye-tracking study of the intradimensional/extradimensional set shifting task

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The aim of our study was the online observation of processes related to executive attention during the Intradimensional/Extradimensional Set Shifting task. In this task, participants are required to choose between two compound stimuli with distinct stimulus-dimensions (e.g. shape, colour) based on feedback provided for their previous decisions. The stimuli and the rule which determines the correct response changes during the task: the dimension determining the correct response remains the same during intradimensional shift (IDS), whereas it changes during extradimensional shift (EDS).

We adapted this task for eye-tracking by creating stimuli in which the two stimulus dimensions are separated in space (different geometrical figures with differently shaped holes inside). As a result, we could determine from the gaze pattern which stimulus-dimension was attended by our participants. Our results add important information to understanding the online processing mechanisms of attentional set shifting by showing that in the ED-stage, accumulating dwell time on the relevant dimension predicts successful extradimensional shift. Moreover, visual attention on the irrelevant stimulus dimension in the early stages of the task determines success later in the EDS-stage (when this dimension becomes relevant). This suggests that vigilance to new stimulus features is a key determinant of attentional set shifting.

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Non-visual Eye Movements: Data Acquisition and Relationship with Memory

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There is evidence that saccadic eye movements (EMs) people make while thinking are systematically related to internal thought processes. In thought processes that involve long-term memory (LTM) search, eyes move on average twice as frequently as when such search is not required. This pattern can be found in face-to-face situations, in the dark, when the eyes are closed, and with verbal and non-verbal information. Significantly more EMs occur in retrieval than in recognition tasks further suggesting that this oculo-motor activity is triggered by memory search. Because these EMs do not appear to be related to visual processing, we refer to them as non-visual eye movements (NVEMs). NVEMs can be assessed using eye movement rate (EMR) and a novel measure - EOG power (EOG-P). EMR is based on visual scoring of EMs from video and EOG recordings. EOG-P is computed from frequency and amplitude of EMs recorded with EOG. Both measures detect significantly more EMs in long-term memory than in working memory tasks regardless whether the eyes are open or closed, and are highly correlated when the eyes are open. Finally, we discuss a neuroanatomical link between saccadic and memory systems, and consider the importance of NVEMs as markers of cognitive function.

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Measuring the effectiveness of flag advertisements in comparison to roll-up advertisements using eye tracking technology

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Despite the fact that new methods of advertising like banner ads or pop-ups are increasing constantly, numerous companies are still using flags to attract customer attention. Particularly car dealers, gas stations, shopping malls, banks or furniture stores rely on this established advertising method. Therefore consumers often are – consciously or unconsciously – confronted with flag advertising. Although literature provides many publications on the advertising impact of different means of promotion, only few publications discuss the advertising effect of flags. The study aimed to determine the effectiveness of special air-moved flags in comparison to roll-up advertisements. The attention level of 120 test persons was identified in a real environment using new eye tracking technology. In the experiment the test persons were split up into two different groups and were unconsciously confronted with either a flag or a roll-up advertisement with the same imprint. To improve the significance of the results, further a questionnaire was introduced. In the course of the study the authors found that the test persons confronted with flags on average paid attention longer and in a more focused way than those confronted with roll-ups. Moreover the test persons perceived flags as a 'more enjoyable' advertising method.

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Follow Buzzy Bee: The effects of arrows, eye gaze and finger pointing cues on saccadic orienting in infants

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Little is known about the developmental trajectory of saccadic orienting caused by eye gaze, finger pointing and arrow cues in young children, although many studies have shown that adults' attention and saccades are facilitated in the direction of these cues even when uninformative. We have developed a pro-saccade task designed for children. Children were instructed to ignore cues presented at fixation and saccade towards a cartoon bee (the target) which appeared randomly to the left or right of fixation irrespective of the direction of the central cue. Thirty-six children aged 4 to 10 years completed 56 trials. A mixed-measures ANOVA showed an interaction between Age, Cue type and Congruency ($F_{4,66} = 3.75$, $p = .008$) with 4-5 year old children displaying a 70ms congruency advantage for pointing cues, but no advantage for eyes or arrows. Children aged 6-7 and 8-10 years showed cueing effects for all three cues. Linear regression revealed that Age was a significant predictor of cueing effect for pointing cues. These findings suggest that pointing is an influential cue in young children, but that automatic orienting to arrows and gaze does not develop until age 6 years.

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Attention to Different Elements in Print Advertisements: The Influence of the Viewer's Goal

Kristina Nenova & Evgeniya Hristova
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The purpose of the current study was to provide evidence about the influence of the viewer's goal on the attention dedicated to several ad elements - text, picture, product, and brand. Two experiments demonstrate that the participants pay more attention to the text elements of the ads. In Experiment 1 participants were shown 18 ads in a self-paced presentation while their eye-movements were recorded. They had the task to decide how much they liked the ad or the product. We found no significant differences with respect to the task. In both conditions participants spent more time looking at the text and at the picture than at the product and at the logo (text and picture did not significantly differ in terms of the looking time). Gaze time analysis relative to the size of the area indicated that text attracts the most of the viewers' attention, followed by the brand and product. However, the picture element was the first one noticed. In Experiment 2 participants were presented with 4 ads of lifting creams and had to choose one of the ads or one of the products. There was no influence of the task. Gaze time was longer for the text elements.

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Visual Search for Differences: the Impact of Facial Expression and Background Music

Yuhua Shi & Izabela Krejtz
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Emotional facial expression, even unconsciously, can guide visual attention. Based on previous research, this experiment (N=61) examined whether presence of emotional facial expression in a finding-difference game affects visual search, and how it interferes with a background music. In the background of happy, sad or no music, participants were asked to find and remember five differences on each pair of pictures (positive, negative, and neural) within 40 seconds. The results suggested first if the picture has emotional expressions on it 1) participants looked more on face areas than difference areas, 2) noticed less differences on emotional than neutral pictures. Second when happy music was playing on 3) participants move their eyes faster 4) and found less difference than listening to sad music or in silence. And third, 5) females were easier to be disturbed by music than males while scanning emotional images. In general, the finding indicated that emotional expressions played a role of attention attractors, biasing searching process. The background music influenced the memory of the differences. The findings are in line with the previous studies that emotional expressions can modulate attention and shed a new light on the interaction between emotional facial expression, emotional background and temporal attention.

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Posters

Clinical Studies

Friday, August 16, 12:20 - 13:30

Room: Stora salen (2nd floor)

Facilitation of reflexive saccades and enhanced performance in voluntary saccadic task in Parkinson's disease

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Effect of Parkinson disease (PD) on saccadic eye movements is debatable. Studies have reported impairment, normal and hyper-reflexivity of saccadic eye movement in Parkinson disease. To investigate the role of cognitive control on saccadic eye movements we compared performance of reflexive saccades and voluntary saccades in patients with Parkinson's disease and age matched controls. Saccadic eye movements were recorded by an infrared based Arrington Viewpoint eye tracker system (ARRINGTON RESEARCH, Inc. USA). Images of the dark pupil was captured which was created by the reflection of the infrared light from the eye. Reflexive and voluntary saccadic tasks were administered to subjects. Latencies, gain, errors and peak velocity of saccades were measured. PD group showed hyper-reflexivity which was reflected by abnormal facilitation of latencies of reflexive saccades. PD group also showed enhanced performance making less error in voluntary saccade gap task. Both reflexive and voluntary saccades were hypometric in PD group as compared to controls. We attribute facilitation of reflexive saccades and enhanced performance in voluntary saccades to early fixational disengagement from fixation in PD patients as compared to controls. Overall hypometria in PD is suggestive of excessive dopamine depletion in PD group.

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Tea with milk and sugar: gaze and action coordination in a real-world task in Parkinson's disease

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In real-world tasks, there is often an asynchrony between fixations on objects and manual operations: gaze often precedes and guides actions. We assessed whether such coordination is preserved in Parkinson's disease. Participants were asked to make a cup of tea with milk and sugar, while seated in front of a tray containing the required items. Valid data was obtained from 9 aged controls, 11 people with Parkinson's and normal cognition (PDN), and 8 with PD and mild cognitive impairment (PD-MCI). Behaviour was scored by analysing the gaze cursor superimposed on 25 Hz scene videos recorded via a head-mounted SMI mobile eye tracker. Parkinson's participants took longer to complete the task but the primary dependent variable was the time between fixating on the cup relative to each of the tea, milk or sugar beginning to flow into it. There were strong task effects: cup fixations generally lagged tea flow onset but occurred close to milk flow onset and preceded sugar flow. The Parkinson's groups showed an overall pattern similar to the controls but had a larger number of individuals with markedly early cup fixations. Adding a group with Parkinson's dementia will give a fuller picture of gaze coordination in this disorder.

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Eye movement behavior during reading in patients with probable Alzheimer disease.

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Reading is an everyday activity requiring the integration of several central cognitive subsystems ranging from attention and oculomotor control to word identification and language comprehension. Several of the associated cognitive processes such as working memory and retrieval memory are known to be impaired in Alzheimer's disease (AD). This study analyzes eye movement behavior of 18 patients with probable AD and 40 age-matched Controls during Spanish sentence reading. Controls were found to focus on word properties and consider syntactic and semantic structures; effects of word frequency, length, and cloze predictability on reading times indicate local processing of fixated words. Besides, Control's knowledge about sentence meaning and grammatical structure is quite evident when we consider visual exploration. In the AD group, visual exploration was less focused; fixations were much longer and saccade amplitudes were smaller than in Controls. In addition, the upcoming word predictability effect was absent in the AD group. The altered visual exploration might be related to impairments in working memory and long term memory retrieval functions. These eye movement measures demonstrate considerable sensitivity with respect to evaluating cognitive processes in Alzheimer. They could provide a user-friendly marker of very early disease symptoms and of its posterior progression.

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Effect of eye orientation on visual acuity in infantile nystagmus (INS)

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Purpose: People with INS have, from an early age, a continuous horizontal oscillation of the eyes that is associated with poorer vision. Most subjects display a brief slowing of their movements when the fovea is on or near the target (i.e. foveation). In addition, these repetitive eye movements change in amplitude and/or frequency (i.e. intensity) with eccentricity. This experiment investigated whether visual acuity (VA) is affected by observed differences in nystagmus parameters.

Methods: Eye movements of 9 subjects with idiopathic INS were recorded using a Skalar Iris tracker, and visual stimuli were displayed on a monitor and presented by means of a computer-motorised mirror to control eye orientation for each presentation. VA for Landolt C's was tested at each eccentricity using a staircase procedure.

Results: All subjects completed trials at three gaze angles, which affected nystagmus parameters. Across subjects, VA was inversely linearly correlated with nystagmus amplitude ($p < 0.005$) but was not affected by changes in frequency. VA was also logarithmically correlated with foveation duration ($p < 0.0001$). However, variations within subjects had no impact on VA.

Conclusion: Eye orientation in INS subjects affects nystagmus amplitude and foveation duration but these changes do not affect VA within a given subject.

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Involuntary saccade initiation is related to the timing of voluntary saccades in infantile nystagmus

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Purpose: Infantile nystagmus, a constant repetitive oscillation of the eyes, has in recent years been found to be influenced by psychological factors, such as visual 'effort' and emotional engagement. Our analysis of nystagmus during a conscious visual task reveals a direct relationship between the timing of voluntary saccades and the initiation of the quick phases of nystagmus.

Methods: Nineteen subjects with horizontal infantile nystagmus underwent high-speed eye tracking whilst performing saccades to vertically displaced targets. Saccade detection algorithms were applied in both the horizontal and vertical axes to determine the timing of voluntary (vertical) saccades with respect to the involuntary (horizontal) quick phases of nystagmus.

Results: Eye trace analysis reveals that quick phases in the horizontal axis either occur in synchrony with vertical saccades, or are 'skipped' altogether (the quick phase is apparently suppressed by the voluntary saccade).

Conclusions: These results show direct modification of the nystagmus waveform in response to a saccadic task, providing evidence that infantile nystagmus is influenced by the voluntary saccadic control system.

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Saccadic latency in functional amblyopia

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In functional amblyopia the loss of physiological quality of central vision is associated with abnormal visual experience (e.g. anisometropia, strabismus) in infancy or early childhood.

This study is aimed on detecting the initially subtle differences in visual information processing between the amblyopic and dominant eye by persons with strabismic and anisometropic amblyopia. Several studies using standard refixation paradigm has already shown the prolongation of saccadic latency in already structural amblyopic eye. However when applying the saccadic latency for central deficits assessment, the stimulation of central retina should be considered as a primary stimuli for evoking the saccadic response, rather then the stimuli appearing in the periphery in standard visual-refixation paradigms.

In order to fulfill this requirement, as first the central fixation stimuli is displayed and after 200ms, additionally appears the peripheral (10 deg) stimuli, indicating the desired saccade landing location. The subject waits until the central fixation is turn off (GO-signal). After the saccade has been executed the peripheral stimuli disappears and the experiment repeats. Pilot study on five subjects with developed anisometropic amblyopia has demonstrated substantial prolongation (60 - 80ms) of saccadic latency time in amblyopic eye in comparison with the dominant eye.

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The effect of interocular luminance differences on eye movements in amblyopia and normal vision

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Amblyopia is a developmental visual disorder that leads to impaired binocular vision. It remains unknown whether amblyopia is the cause or the consequence of the breakdown in binocular vision, however treatment deliberately suspends binocular vision by penalizing the fellow eye with patching or atropine, which forces the use of the amblyopic eye. Penalization creates a significant difference in luminance between the two eyes: patching reduces luminance by occlusion and atropine increases luminance by pupil dilation. We examine how such binocular luminance asymmetries affect eye movements in normally-sighted and amblyopic subjects.

Binocular gaze position was recorded at a sampling rate of 500Hz (EyeLink 2000) while subjects fixated and made saccades to a target dot in four viewing conditions: monocular target in either the fellow eye or the amblyopic eye while either a high or a low luminance blank background was presented to the other eye. Our preliminary results show that compared to normally-sighted observers, subjects with amblyopia exhibit significantly reduced fixation stability (Bivariate Contour Ellipse Area) and impaired fixation accuracy for the amblyopic eye viewing condition. Furthermore, interocular luminance difference impaired fixational eye movements of amblyopia, suggesting a possible adverse effect of penalization treatment.

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Computerized tests for vergence performance screening at schools

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Using computerized tests to evaluate vergence performance (fusion reserves and vergence facility), it is possible to improve binocular problem screening at schools. To evaluate, which test would be more appropriate for screening, we measured fusion reserves and vergence facility in 65 children (7-17 y.) using classical method (prism bar and 12△ base out/3△ base in) and computerized tests based on random dot (RDS) technique and tranaglyphs. Comparing all three methods, NFR showed no significant difference between methods ($p < 0.05$), but PFR showed significantly smaller average value, measured with tranaglyphs than classical method ($p < 0.001$). Both computerized tests showed good differentiation between subjects with decreased and normal fusion reserves, defining approximate norms of fusion reserves for each age group. By evaluating vergence facility, it was harder for children to keep proper vergence performance stimulated with base out prism, independent of the prism size used (12, 8, 4 pd). Comparing classical and computerized methods, we observed significantly different results ($p < 0.001$). Thus, computerized vergence facility measurement will produce too many vergence problems even among children with good vergence performance. It seems to be easier to perform and to understand fusion reserve tests were RDS stimulus presentation is used.

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Does landing point probability manipulation abolish the antisaccade cost?

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Antisaccades are saccades made in the direction opposite to a peripherally presented target. They are typically slower than saccades towards such a target by 50 to 100 ms. Antisaccades have proved to be an important diagnostic tool in neurology, psychiatry and psychology, providing invaluable insights into attentional function, decision making and the functionality of eye movement control (Antoniades et al., 2013). Recently exciting findings were reported which suggest that latency differences between pro- and antisaccades can be eliminated by manipulating landing-point probabilities (Liu et al., 2010). Liu et al. reported that antisaccades and prosaccades were equally fast to low-probability landing-points. Such modulations could therefore potentially yield further clinical insights. Here we tested effects of landing-point probability manipulations for a number of different pro- and antisaccade tasks of various difficulty levels. Probability manipulations were only found to modulate antisaccade costs in a very difficult antisaccade task where target saliency was low and latencies were long (600 ms). For other tasks including standard ones from the literature, landing-point probability asymmetries have minimal effects. We propose that probability modulations of antisaccade costs may reflect effects upon decision making rather than saccade generation. This may limit their usefulness for clinical purposes.

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Relationship between prefrontal cortex deficits and Antisaccade Errors in Antipsychotic-naïve Schizophrenia

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BACKGROUND – In Schizophrenia, antisaccade task performance difficulties have been implicated upon dorsolateral prefrontal cortex (DLPFC) deficits. In this study, we examined the correlation of gray matter volumes of DLPFC and antisaccade error (ASE) rates in schizophrenia patients and healthy controls. We describe the first report of DLPFC volume correlates of ASE in schizophrenia.

METHODS – Nineteen DSM-IV Schizophrenia patients (M:F=12:7; Age=30.5±7.0-Years) [15-antipsychotic-naïve/free] and 24 healthy controls (HC) (M:F=13:11; Age=26.5±2.8-Years) were examined. Eye movements were recorded with EyeLink 1000. Using structural MRI (1-mm thickness), DLPFC gray matter volume (GMV) was compared, and correlated with ASE rates using Voxel Based Morphometry in SPM8.

RESULTS – Schizophrenia patients (35.3±11.5) showed significantly greater ASE than HC (21.0±11.5) ($t=3.9$, $p<0.001$); left DLPFC GMV was significantly deficient in patients (X= -9, Y=50, Z=34, p(uncorr)<0.001). ASE had a significant negative correlation with right DLPFC GMV in patients (X=47,Y=26, Z= -6, p(uncorr) <0.001) and with left DLPFC GMV in HC (X= - 45, Y=3, Z=40, p(uncorr) <0.001) [Small volume correction-FWE corrected $p<0.05$].

CONCLUSIONS - This study emphasizes the role of the DLPFC in the generation of correct antisaccades and suggests that GM deficits in DLPFC associated with schizophrenia might underlie poor performance on this task.

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Trait Impulsivity & Antisaccade Performance

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Impulsivity is a personality trait described as a tendency to act without adequate thought. It plays a vital role in behaviour and is commonly prevalent in several Psychiatric disorders including; Attention-Deficit/Hyperactivity Disorder (ADHD). There is growing consensous that impulsive behaviour maybe realised through several personality-pathways, suggesting that the trait is multi-dimensional in nature. Researchers are begining to explore how these different dimensions of impulsivity relate to cognitive functioning, e.g. inhibitory control. When using behavioural tasks, several studies have found inhibitory control deficits in people with high levels of impulsivity. Comparatively, little is known about the relationship between oculomotor inhibiton and trait impulsivity in healthy participants. The aim of this ongoing study was to determine whether high-impulsive and low-impuslive participants would demonstrate differences in their ability to inhibit prepotent eye movement responses. Impulsivity was measured via two self-report questionnaires and oculomotor inhibiton was measured using an antisaccade task. Results showed a negative relationship between impulsivity and antisaccade errors, but only for certain subscales. Those with low impulsivity scores made more antisaccade errors. As expected, latencies did not correlate with impulsivity. These findings suggest that only specific types of inhibitory deficits are linked with impulsivity in the healthy population.

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Eye Movements and Visual Perception in Children with Learning Disability

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Visual information processing problems and visual - perceptual deficits are usually common problems in children with learning disabilities;many studies indicate that basic visual functions specially eye movements are one of the most affective factors in visual learning and reading achievements. This study is designed to assess if there is any correlation between saccadic eye movements and visual perceptual skills. Materials & Methods To examine whether saccadic eye movements can affect visual perceptual skills in children with learning problems, 51 learning disabled student (7-11 years old) were selected from Tehran Special Learning Disability Centers. Visual perceptual skills were measured by Test of Visual Perceptual Skills-Revised (TVPS-R); also Developmental Eye Movement test (DEM) was applied to evaluate vertical and horizontal saccades and reading errors. The results were analyzed by Pearson's and Spearman's correlation coefficient. Results The results of simple correlation indicate that perceptual ages in figure ground discrimination and visual closure have significantly negative correlation with vertical and horizontal times of saccadic eye movements; in addition there is a significant negative correlation among perceptual ages in figure ground discrimination, visual closure, form constancy and number of errors that happen while reading.

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Semantic processing differences in Autism Spectrum Disorder: Evidence from eye movements and reading

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The aim of this experiment was to examine semantic processing in adults with Autism Spectrum Disorder (ASD). Research into reading in ASD has predominantly employed offline techniques that give no insight into the online processing differences that may exist in ASD, and potentially reflect frequently reported comprehension difficulties. We recorded the eye movements of participants with and without ASD as they read sentences that were manipulated to include plausible (control condition), implausible (possible but highly unlikely) or anomalous (impossible) thematic relations. Preliminary findings indicate that the fixation patterns of the control and ASD groups did not differ when reading plausible sentences, but when reading implausible and anomalous sentences the ASD group showed a delayed disruption to reading. The semantic violations resulted in almost immediate disruption in the control group, as seen in first and single fixation durations, whereas the ASD group showed disruption in later stages of processing as indexed by go past and total reading times. The findings suggest that ASD readers may be less efficient at constructing an interpretation of a sentence and evaluating it against their world knowledge, and are in line with the Theory of Complex Information Processing in ASD (Minshew & Goldstein, 1998).

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Eye Movements and Figure Copying in Autism Spectrum Disorder

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People with Autistic Spectrum Disorder (ASD) have previously achieved superior performance on tasks that require an attention to detail, or local-processing bias, coupled with reduced task performance when an overview of the Gestalt is required. However, this finding is far from universal; especially for participants with ASD that have an average to above average level of general intellectual functioning. The current study used both eye tracking methodology and the Boston Qualitative Scoring System to investigate the potential presence of a local-processing bias during completion of the Rey-Osterrieth Complex Figure (ROCF). Eleven participants with ASD and 11 typically developed (TD) control participants matched for age, sex, and general intellectual functioning copied the ROCF whilst their eye movements were recorded. A local-processing bias was not found in any of the eye movement measures and there were no differences in how the two groups sampled and reproduced the ROCF. However, the level of self reported Autistic traits in the ASD group correlated positively with the time taken and the number of fixations prior to fixating a part of the figure that is often described as a 'face'. The findings are discussed in relation to current contemporary theories of information processing impairments in ASD.

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Eye movements during processing of written irony in Autism Spectrum Disorder

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Previous research has shown that typically developed (TD) readers have longer reading times for ironic statements compared to when the same statement is presented in a non-ironic context, indicating increased processing when the statement was intended ironically (Filik & Moxey, 2010). Benson, Castelhano, Au-Yeung, and Rayner (2012) showedindividuals with Autism Spectrum Disorder (ASD) have difficulty processing ambiguous information in scene perception tasks. There are no eye movement studies investigating how individuals with ASD process ambiguous information (such as ironic statements) in reading. In the current study, we presented TD and ASD participants with three sentence paragraphs containing a statement that could be interpreted either ironically or non-ironically depending on the preceding context. We predicted that ASD participants would be less likely to pick-up the ironic statement at the initial encounter (e,g, shorter first-pass reading times) compared to TD participants. Furthermore, processing difficulty of the irony should be reflected in longer total reading time and increased regression path time in ASD. No between-group differences in processing of the text containing the non-ironic statement should occur. The results will be discussed in relation to the theory of Complex Information Processing Disorder in ASD (Minshew & Goldstein, 1998).

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Anxiety, eye movements and visual search for emotional faces

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The current experiment explored the relationship between young adults' self-report scores of individual differences in personality, anxiety and attentional control with the detection of threatening (angry faces) and non-threatening (happy and neutral faces) stimuli. On target present trials, a target face was presented with either one, three or eight distractor items. On target absent trials all items were distractors. Participants were asked to indicate the presence or absence of angry, happy or neutral faces as quickly and accurately as possible and reaction times and eye movement measures were recorded. Preliminary analysis showed a typical profile of reaction time and error responses associated with making present and absent judgements in visual search that was moderated by emotion, where search was more efficient for angry faces. Similarly, global measure of eye movements highlighted that the number of saccades was moderated by emotion, highlighting that fewer saccades were made in the angry condition across all set sizes and for both present and absent trials. In contrast to previous research, the study showed no consistent relationship between reports of individual difference with behavioural or eye movement measures of search.

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Emotional Face Processing in Depressed Older Adults

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Although several studies have suggested that younger adults with depression display a mood-congruent bias in the processing of emotional faces, there is a lack of data about emotional face processing in depressed older adults. In this eye-tracking study, older adults with and without depression viewed happy, neutral or sad portraits while eye movements were recorded. We investigated gaze fixations and duration in emotional (i.e. eyes and mouth) and non-emotional face areas. Depressed older adults spent less time and had fewer fixations on emotional areas than healthy older adults, but only for sad and neutral portraits. There was no significant difference between the two groups for happy portraits. These results suggest a disengagement from sad and neutral faces in depressed older adults, which is not consistent with mood-congruent theories of depression. Emotional regulation changes related to aging may explain the influence of age on depression-related biases. Our findings suggest that a steady congruence bias in depression is not generalizable to all developmental stages.

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Relationship between eye movement patterns, cognitive deficits and symptom severity in obsessive-compulsive disorder (OCD)

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Obsessive-compulsive disorder (OCD) is a psychiatric disorder characterized by repetitive intrusive unwanted thoughts (obsessions) and repetitive behaviors (compulsions). Previous studies pointed out that the main cognitive deficits in OCD manifest in inhibition, set shifting and spatial working memory functioning (e.g. Chamberlain et al., 2005; van der Wee, 2003; 2007). We developed computer-controlled paradigms to investigate the eye movement correlates of these cognitive processes. A group of OCD patients and a group of healthy control participants were screened with the Penn State Worry Questionnaire (PSWQ), the Vancouver Obsessive Compulsive Inventory (VOCI), and the Strait-Trait Anxiety Inventory (STAI). Symptom severity in the OCD group was assessed by the Yale Brown Obsessive Compulsive Scale (Y-BOCS). All participants completed a neuropsychological test battery of tasks measuring executive functions, visuo-spatial and verbal working memory capacities. During data analysis we have focused on the possible relationship between eye movement patterns (saccade latencies and viewing patterns), cognitive deficits and symptom severity. We will discuss the results in the framework of an integrated working memory model.

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Theory of cerebellar supervised learning of compensation for the nonlinear position-dependent elastic restoring forces in the orbit

Masahiko Fujita
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The position-dependent saccadic dysmetria after lesions of the saccade-related areas of the cerebellar cortex suggests the failure of compensation for the position-dependent elastic restoring forces in the orbit. The mechanism responsible for compensation seems to send to the eye different innervation changes for the same retinal target error, depending on where it is in the orbit and which way it is going. This mechanism seems to be also responsible for the adaptive adjustment of saccadic parameters. A theory of single-input version of cerebellar function has already been applied to the suppression of the endpoint variability of saccades (Neural Computation, 2013). Here a multiple-input version of the theory is proposed which can execute the compensation mentioned above. It is assumed that one of the two mossy fiber inputs of the cerebellar model encodes a saccade command and the other encodes the eye position in the orbit. The theory assures that the supervised learning of the model can generate a voluntary output function of the two inputs, and the computer simulation study has confirmed the proper adjustment of the intensity of saccade commands depending on the eye-position in the orbit. Experimental tests are necessary on the validity of the model.

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Using an Eye Movement in Desensitization and Reprocessing therapy for the treatment of chronic pain

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The complex part of cognitiv, behavioral and emotional in chronic pain make treatment complicated. Since few years, many authors have argued on a traumatic symptomatology who be responsable of chronic pain (reactionnal symptom of Post Traumatic Stress Disorder -PTSD), or that chronic pain may induce a trauma.

In 1989, Shapiro created the Eye-Movement Desensitization and Reprocessing therapy. Based on the eye-movement on REM sleep, this therapy show efficiency in the treatment of PTSD. Eye-movement seems to be helping to reprocessing traumatic emotions and cognitions about traumatic events.

One study about using EMDR on chronic pain, already shows interesting results (Mazzola, Calcagno, Goicochea, Pueyrredon, Leston & Salvat, 2009).

This research aims to test the effectiveness of treatment of chronic pain with a specific EMDR pain protocol (Grant & Threlfo, 2002) (n=15), compared to an EMDR standard protocol (Shapiro, 1995) (n=15), and eclectic therapy (control groupe) (n=15).

After every session, and at the end of the treatment, the effects of EMDR protocol on chronic pain and traumatic symptomatology were evaluated and show significant improvement.

The use of various EMDR protocol and the role of eye-movement will be discussed.

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An investigation of the relationship between individual differences in infant fixation durations and later temperament and behaviour in childhood

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Individual differences in attention in infants have been related to several forms of later psychopathology. Research has indicated that fixation duration is a reliable measure of attention and is correlated with individual differences in cognitive performance both in infants and in children. The current longitudinal study attempted to associate mean fixation duration in infancy with questionnaire data collected in early childhood. One hundred infants completed eye-tracking tasks (mean age 7 months). Parents completed measures of behaviour problems and temperament at follow up (mean age 42 months). Eye-tracking data were recorded using a Tobii-1750 eye-tracker. Fixation duration was detected using fixation detection algorithms in Matlab. Hand coding was performed to the results derived from the algorithms in order to clean and validate the measure. Preliminary results showed that mean fixation duration in infancy was significantly correlated with the temperament scales of anger ($r = -.32$, $p < .005$), smiling ($r = -.32$, $p < .005$), shyness ($r = .34$, $p < .003$) and surgency ($r = -.32$, $p < .005$). Fixation duration was negatively correlated with behavioural problems but the correlations were not significant after correction for multiple testing. The genetic origins of these associations will be investigated in follow-up work.

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Posters

Eye movements & language

Friday, August 16, 12:20 - 13:30

Room: Stora salen (2nd floor)

Language competition in L3 speech recognition in trilingual speakers

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Past eye-tracking research with bilingual speakers has shown that both languages seem to be activated in parallel and compete in speech recognition (Spivey & Marian, 1999; Marian & Spivey, 2003; Weber & Cutler, 2004; Ju & Luce, 2004; Canseco-Gonzalez et al., 2010; Shook & Marian, 2012). In the present study we used the visual world paradigm to investigate language competition in proficient trilingual participants (Polish-English-Russian). The participants were instructed (in Russian) to click on pictures of objects presented to them on the computer screen. Each target picture (to be clicked on) was accompanied by either 3 unrelated pictures (control condition) or by 2 unrelated pictures and 1 between-language competitor. The number of fixations on objects whose names were phonologically similar to the target object in the native language (between-language competition in Polish), the other foreign language (between-language competition in English) was compared to the number of fixations in the control condition where no pictured object was phonologically similar to the target. Preliminary results indicate that trilinguals tend to look on Polish between-language competitors but not on English between-language competitors when hearing Russian targets.

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The eyes follow the sound: Measuring speech perception with eye-tracking

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Infant speech perception is known to undergo critical changes before the first year of life: young infants are able to discriminate non-native speech contrasts, whereas older infants and adults lose this ability by attuning to the native language (Werker & Tees 2002; Kuhl et al. 2005). Much of this research was conducted using the Conditioned Head Turn (CHT) procedure (Werker et al. 1997). In the current study we developed an eye-tracking version of CHT, by exploring anticipatory looking (AL) behavior to auditory stimuli (Bjerva et al. 2011). Portuguese adults and infants were trained to learn an audio-visual contingency consisting of a native sound change (/pa/ vs. /ka/) paired with an attractive video (VAOI). Video onset was progressively delayed relative to sound change onset, triggering AL to VAOI. Time to first fixation within VAOI showed that both adults and infants presented AL behavior. This allowed us to test discrimination of a non-native contrast (Hindi /d'a/ vs. /da/). Although showing AL in the native contrast condition, adults presented no AL to the Hindi sound change trials, replicating results from an ABX perception experiment. Preliminary data from infants also suggest the effectiveness of the gaze-based procedure to study speech perception.

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Automatic American Sign Language (ASL) activation during reading in ASL-English deaf bilinguals

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Much evidence suggests that bilinguals activate words in both languages when reading either in their L1 or in their L2. This has been shown across languages sharing scripts (English-French), but also across scripts (English-Chinese). Remarkably, this effect is also found across modalities (spoken vs. signed languages; languages that do not overlap in input/output modalities and that have distinct phonological/structural components). In other words, when confronted with English print, ASL-English bilinguals activate ASL, even if there is no relationship between these languages. The present experiment extended prior research and embedded pairs of unrelated English words for which translation equivalents in ASL were either related (signs that share several phonological/structural parameters in ASL) or unrelated (no overlap at all between the two sign equivalents in ASL) within sentences (RELATED: The cats will be *sick* if they *touch* (target) the plant's leaves; UNRELATED: The cats will be *safe* if they *touch* (target) the plant's leaves.) Eye movement measures on the target words suggest that while reading English sentences, ASL was activated extremely early (effect found in skipping rates and first fixation durations) in deaf ASL-English bilinguals. Interestingly, the time-course of the effect was modulated by the participants' L2 (English) proficiency.

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Do bilinguals exhibit a better inhibition in eye movement task switching? Evidence from pro- and anti-saccade tasks

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A bilingualism advantage has been shown in cognitive tasks involving inhibitory control (Bialystok, Craik & Luk, 2008).These higher inhibition's capacities are assumed to be due to regular use of code switching. Here we questioned whether top-down inhibition trained by a cognitive activity like code switching does impact the realization of motor tasks involving an oculomotor control like the anti-saccade task (AS; Munoz & Everling, 2004). Saccadic responses were measured in 12 monolinguals and 12 late bilinguals. Prosaccades (PS, i.e. automatic response toward the target) and Anticaccades (AS, requiring the inhibition of the automatic PS) were tested in one mixed session (i.e. switch between PS and AS responses) and in two blocked sessions (before and after the mixed session). Results showed that, as expected, PS latencies were shorter than AS ones, in both groups. Moreover, a training effect was found with shorter latencies in the second blocked session than in the first one, but in less extend in bilinguals. Globally, bilinguals were faster than monolinguals. More critically, the switch condition only slowed latencies of PS in monolinguals, but not in bilinguals. Taken together, our data suggest that top-down inhibition trained by a cognitive activity could impact the realization of motor tasks.

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Do eye movements during spatial description encoding correlate with navigational processing and individual differences in spatial abilities?

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The ability to construct mental representations of space from a symbolic description, such as a map or a verbal account, is uniquely human. In the present study we will investigate the encoding of spatial descriptions in order to represent and navigate a novel urban environment. Previous studies have not directly examined the relationship between encoding and spatial performance. We will measure eye movements while participants read spatial descriptions based on egocentric (viewer-centred) and allocentric (world-centred) perspectives. Following the encoding phase, participants will be required to reproduce the route described in map form. We predict that the navigational relevance of the features described (e.g. the locations of landmarks) will be reflected in reading behaviour, including longer fixations and increased refixations of navigationally relevant items. We further predict that navigational relevance will affect memory for route details in the recall phase. Participants will also be presented with an additional battery of individual differences measures, including mental rotation, a self-report measure of sense of direction, and working memory. We will examine whether, and to what degree, any of these basic abilities underlie performance on the task, and whether eye movements reflect individual strengths and weaknesses during encoding of different spatial perspectives.

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Numerical data processing in simultaneous interpreting: An eye tracking study

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Simultaneous interpreting (SI) is frequently perceived as one of the most challenging language tasks (Christoffels and de Groot 2005). Numerical data processing is particularly problematic, since numbers are characterised by low predictability, low redundancy and high informative content (Mazza 2001). From a neurolinguistic perspective, it is the simultaneous activity of different brain areas that causes the difficulty (Dehaene et al. 2003, Gazzaniga 2000). Interpreters themselves report that access to visual materials may reduce the cognitive load related to information storage in the working memory and improve number interpreting.

The dual purpose of the present study was to investigate the extent to which access to visual materials containing numerals would facilitate SI performed by conference interpreting trainees and the strategies used. A group of interpreting trainees were asked to interpret two speeches in the simultaneous mode. Only one of them was accompanied with the slides, which had numerical information embedded in three different ways (non-contextualised, as bullet points and in longer chunks of text).

Analysis of data from an EyeLink II eye-tracker and qualitative analysis of the interpreters' performance made it possible to establish the extent to which visual access to numerical information in different forms facilitates simultaneous interpretation of numbers.

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The scene semantic consistency effect of eye movements during spoken language comprehension

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The purpose of the present study was to investigate how semantic consistency in complex visual scenes influence eye movement control during spoken language comprehension. Previous studies have shown that there exists a linkage between look and listen. Furthermore, scene perception studies suggest that scene gist can be accessed within a glance, subsequently attracting eye fixations on semantic inconsistent objects. The present experiment used visual world paradigm to examine how the semantic consistency between visual object and background dynamically influences eye fixation patterns in a 'look-and-listen' task while comprehending a spoken sentence. In each trial, participants heard a spoken sentence which included the name of a target object (e.g., The house-owner mistaken the tiger as a cat. . .). A picture was showed either at the time or one second before the onset time of the target. For the scene, the named target (e.g., tiger) was embedded in one of three backgrounds: semantically consistent (e.g., field), semantically inconsistent (e.g., sky) or blank. Participants fixated more on the target object embedded in semantically inconsistent and blank background than in semantically consistent one during language unfolded. These results suggest both spoken language and scene semantic consistency conspire to guide viewers' eye movements during comprehension processes.

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Auditory noise as a fast trigger for speech-reading

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Previous research has found that normal-hearing adults direct more visual attention to the visual correlates of the articulators when the speech signal is noisy (e.g. Vatikiotis-Bateson, et al. 1998). We conducted an experiment investigating whether normal-hearing adults use this strategy even in a task which is not centered around speech-reading and where this behavior is particularly difficult to perform. One key question is whether this strategy has been automatized to the degree that noise onset is a fast trigger for speech-reading behavior or whether the behavior is a slow adaptation to an environment of uncertain auditory quality. We find that our normal-hearing adults, despite the challenging stimuli, perform speech-reading even in scenes hard to speech-read and where the task does not require speech-reading. However, the effect peaks at around 500 ms, which is a fast adaptation, but still slower than expected – enough time to perform around two saccades to new targets. 85 % of all participant showed eye movements consistent with speech-reading behavior. A reaction to even pure noise suggests participants have learned to associate noise with a look-up behavior in communicative settings.

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Eye-tracking post-editing behaviour in an interactive translation prediction environment

Mesa-Lao Bartolomé
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Post-editing machine translation is becoming a common practise within the localization industry as opposed to full human translation. Improving the potentials of a post-editing workbench is thus one of the priorities set by both the industry and researchers when addressing the technological challenges faced by translators. This paper reports on a preliminary pilot test within the CasMaCat project. Based in user activity data (key-logging and eye-tracking), this project aims at defining the functionalities of a new translator's workbench focusing on post-editing and advanced computer-aided translation methods. The main aim of this preliminary pilot was to assess one of the new features implemented in the second prototype of the workbench: the interactive translation prediction (ITP) feature. This ITP feature is set to provide translators with different suggestion as they post-edit. For this purpose 6 translators were asked to post-edit 1,000 words from English to Spanish in five different tasks while their eye movements were being tracked. Each task was designed to test different modalities of ITP. Translators were also asked to fill out a questionnaire expressing their attitudes towards each ITP modality. Eye-tracking data was used to correlate participant's satisfaction with ITP and the post-editing behaviour revealed by the eye-tracker.

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Multimodal processing during simultaneous interpreting - evidence from an eye-tracking study

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Simultaneous interpreting is a complex cognitive task requiring the interpreter to comprehend verbal input in one language while producing verbal output in another. The complexity of the task gets compounded when along with the auditory verbal input the interpreter is confronted with visual verbal input, as is the case when a manuscript of a speech is available. While different theories exist about the way in which multimodal information is processed during simultaneous interpreting, little is known about the way in which simultaneous interpreters attend to the different channels of information available to them.

In this exploratory study we set out to analyze gaze-patterns during a simultaneous interpreting task in which professional interpreters are confronted with information delivered on three discrete channels. The image of the speaker will provide visual spatial information, the audio recording of the speech will provide auditory verbal information while the transcript of the speech will provide visual verbal information. A time-locked analysis of input, output and eye-gaze patterns will allow us to infer what channels are attended to at what time. The results of this study are expected to reveal processing patterns with a potential to inform research on the simultaneous interpreting process.

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Written Sentence Production: Evidence from Eye-Tracking and Keystroke-Logging

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The experiment reported here involves collecting keystroke and eye-movement data in a task adopted from the spoken-production literature (Smith & Wheeldon, 1999) combined with detailed statistical modelling to explore the time course of production. In addition to the eye-tracking data, keystroke logging gives information on both initial latencies, and latencies for mid-sentence words and mid-word characters. The combination of eye-tracking and key-logging therefore allows the testing of detailed hypotheses about what is planned when.

Participants were presented with arrays of 2–6 objects, leading to sentences with varying syntactic complexity. Consistent with data from oral naming, longer sentence-initial latencies for complex-simple sentences ("The A and the B are above the C") than for simple-complex sentences ("The A is above the B and the C") were found. Arguably, this suggests planning scope extending over the initial verb-argument phrase, with less processing of the remaining object(s). However this effect was only present when the stimulus objects disappeared at typing onset. If the objects remained visible, the initial planning scope seems to be reduced to the first noun phrase. Though, participants show longer keystroke-intervals at the beginning of the verb phrase. This incremental pattern is usually preceded by eye-movement towards the stimulus.

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Posters

Hardware

Friday, August 16, 12:20 - 13:30

Room: Athen (ground floor)

Eye movement companion – oculometer dedicated for university laboratories and individual PhD students

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There is an increasing acceptance that the eye movement analysis can be used not just as clinical tool but also more importantly further expand our knowledge about the human cognitive capabilities. Albeit such awareness, students of the universities which are on the front line of neuroscience are not getting adequate exposure on the richness of information potentially carried by the eye movement signal. The best way of teaching it, would be letting the students to discover it themselves by providing for everyone of them the environment for conducting individual research projects.

We have developed the measuring system which potentially can serve that purpose. It is an IR reflection eye movement acquisition system which unites design experiences gained over 25 years of developing numerous embedded eye movement systems, addressed for the outside laboratory use. It is optimized from the point of view of the cost, but without sacrificing the highest metrological qualities, providing X/Y measurement with 1 minute angular resolution within +/- 40 degrees horizontal, and +/- 30 degrees vertical ranges and 1ms time resolution. To stimulate student creativeness the system is complemented by the library of inspiring experiments, and software development kit for flexible transformation and design of own experiments.

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Eyefant – eye movement for infants, design consideration and decisions

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The trivial statement that the child is like an adult but reduced in size may result in erroneous assumption that reducing the geometrical dimensions of an adult oculometer should be adequate. Meanwhile, the critical design consideration is the physical interface of the instrument to the child tissue, potentially causing pressure concentration resulting in discomfort and leading to measurement disturbances. The differences in the child head morphology, especially within an area of the nose bridge and eye cavities, requires different approach to anchoring the sensor assembly in relation to the eye axes.

Equally critical is a communication with an infant subject, which depending on the level of development cannot follow the instructions, what is usually expected from an adult, when setting and adjusting the system. Children are born to move, meaning that they will never sit still watching the screen. Their natural motility should be taken into account and because it results in VORs, should be included into the list of measured signals.

A practical attempt to resolve the above listed requirements and constraints will be presented as the first approximation of design decisions, which resulted in the IR oculometer system dedicated for toddlers and younger children, which we named Eyefant.

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OpenSesame opens the door to open-source and user-friendly eye-tracking research

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Eye-tracking experiments can be difficult and time-consuming to implement. Here we present a solution to this problem: OpenSesame, an open-source graphical experiment builder for the social sciences with an active community. We developed a set of graphical plug-ins that allow users to rapidly implement eye-tracking experiments with EyeLink (SR Research) or SMI equipment, without need for manual coding. Other eye trackers can be used through Python inline scripting, using any external Python library. On top of this, we have added support for gaze-contingent paradigms, which are notoriously difficult to implement properly due to their complexity. A number of often-used paradigms have been pre-implemented for immediate use within the graphical interface, whereas the construction of new designs is possible via a built-in high-level Python library, allowing users to create an experiment partly by pointing and clicking, and partly by using Python code, all within the GUI. Using this new functionality, a user can create a complicated gaze-contingent experiment, such as a reading task with a forced retinal location, in under an hour. During the poster presentation, an eye tracker will be present for demonstrations.

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Adaptive Template Matching for Low Resolution Eye Tracking

Detlev Droege & Dietrich Paulus
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A broad range of commercial eye tracking devices is available to be used in gaze interaction systems. These devices often surpass not only the required accuracy for this task, but also the limited budget for affected users. While surprisingly simple and powerful solutions using off the shelf components exist for head mounted setups, the demand for inexpensive remote eye trackers is still unmet.

The key task to be solved for every eye tracker is the determination of the pupil center and the glint center in the acquired image. For systems using off the shelf cameras in a remote set up this needs to be accomplished with sub-pixel accuracy from low quality and low resolution images.

Previous work showed that algorithms developed for high resolution systems do not properly scale down for low resolution systems. Since most feature based approaches suffer from the small number and quality of detectable features we present a method using 'analysis by synthesis'. Based on initial estimates an artificial eye image is generated and compared to the original. The estimates are refined and the generation parameters (e.g. color) are stepwise adapted to best match the analyzed image. The new algorithm is evaluated against other established methods.

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Inclusive saccadometry – measurement of saccadic responses in challenging environments

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Dynamics and latency of saccadic refixation is considered as a sensitive, quantitative marker in a number of neurodegenerative diseases, possessing unique feature of being objective and resistant against the voluntary manipulation.

Authors present the Saccadometer – the robust, mobile system integrating the delivery of saccadic stimuli, according to a list of predefined experiments, the infrared reflectometric eye movement transducer and online saccadic detection used for closed loop control of experiment progress, complemented by software identifying saccadic onset and landings with 1ms resolution. System is setup automatically, and don't require individual adjustments, while maintaining zero invasiveness. Key innovation brought by the saccadometry system is opening the possibility of collecting large populations of saccadic responses, in the physiologically shortest examination time, thus allowing the complete statistical description of saccadic latency distribution.

The focus of the presentation is on design solutions allowing the use of the system in challenging application areas: eye movement acquisition during MRI imaging, where the sensor is made exclusively of plastic, application on infants and young children, applying the saccadometric transducer on subject wearing strong spectacles (without affecting refractive status), and field use under intense sunlight, where usually photoelectric systems become blinded.

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OGTA: Open Gaze Tracker and Analyzer A Remote Low Cost System Based on Off-the-Shelf Components and Open Source Modular Software

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Several academic and commercial eye tracking systems have evolved to the point that they can operate without contact with the user. In addition, they also permit free head movement (within reasonable limits) without losing tracking and maintaining a good accuracy (errors below 1 degree). However, there are still several aspects which require further improvement before these systems can be extensively used. These include price, accuracy, robustness, and ease of set-up and use. This work proposes a preliminary version of a remote eye tracking system which starts to deal with some of those critical points. To drastically reduce the costs, the system has been built by assembling low cost off-the-shelf components, and the cross-platform software has been developed based on an open source philosophy. Second, the accuracy in gaze detection has been improved through the Starburst algorithm. Last and importantly, the plug-in organization of the software architecture, which crucially distinguishes the proposed system from similar ones previously proposed in literature. This facilitates the addition of dedicated software modules designed to improve specific features according to the particular application at hand. Here we present the architecture of the system and preliminary results on the functioning and accuracy of the system.

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Objective Measurements of Visual Acuity in Infants

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Early detection of visual acuity (VA) deficits is critical for the early diagnosis of disorders that affect the eyes and the brain (e.g., amblyopia). Current techniques for assessment of VA are subjective, tedious and require trained observers. Using a remote gaze-tracking system (RGT) that supports robust calibration procedures with infants we developed an objective VA estimation method that is based on the analysis of infant's visual scanning patterns when gratings with spatial resolutions that span the range of sensation from easily visible to invisible are presented to the infant. Binocular visual acuities were measured in 14 infants aged between 3 and 12 months and the results were compared with the clinical gold standard (Teller Acuity Cards -TACs). 93% of the visual acuity estimates of the RGT and the TACs were within 1 octave. Both the TACs and the RGT had repeatability of 86% within 1 octave between two successive visits. 83% of the RGT acuity values were within the 90% normal limits for age although on average the RGT gave significantly better acuity than the TACs (paired t-test, p= 0.011). The agreement between the TACs and RGT and the correlation with age validates the measurements of the gaze tracker.

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A new platform for measuring infants' visual capabilities

Andrea Pratesi, Francesca Cecchi, Stefano Marco Serio, Ilde Barbieri, Cecilia Laschi & Paolo Dario
Scuola Superiore Sant'Anna, Italy

Developmental Disorders (DD) involve a high percentage of children and account for a high number of permanent disabilities with huge costs for the person, the family and the society.

The aim of this work is to develop a new platform for developmental screening that can be used for studying, measuring and analyzing infants' visual capabilities between 3 and 12 months of life. The platform is composed by a mechanical structure with five monitors and speakers for infants' audio- visual stimulation and a gaze tracker to monitor and measure their attention and gaze movements. The five screens are placed in specific positions: one in the center, two on the right side (30° and 60°) and two on the left side (30° and 60°). A specific mechanical structure has been designed in order to fix the screens at specific distances and angles. USB-VGA converters and an external audio device (6 outputs) have been used for the management of multi-monitors signals. A seat has been purposively designed in order to adjust the height and the distance between the infant and the screens. Finally, the SmartEye system with six cameras running at 60 Hz has been chosen as Eye Tracking system.

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A new platform for measuring infants' visual capabilities

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Eye movements are highly correlated with user intention and are often retained by patients with serious motor deficiencies. Despite this, eye-tracking is not widely used as a brain machine interface (BMI). This is possibly because existing commercial systems are prohibitively expensive, restricted to 2D computer interaction and face the Midas touch problem. Using video game hardware, we have developed an ultra-low cost(<€30) binocular eye-tracker with comparable performance to commercial systems 500 times as expensive. Binocular eye-tracking allows 3D gaze estimations, giving a new dimension for end point control of neuroprosthetics. Our volumetric gaze cursor transfers user intention at a theoretical bit rate of 43 bits/second. This is more than ten times that of invasive and semi-invasive brain read-out interfaces that are vastly more expensive. In addition we speed up target selection time by a factor of 5.6, distinguishing non-behavioural winks rather than behavioural blinks to communicate selection. Finally we tested closed loop continuous control, necessary for neuroprosthetics, in a large field study (n=2059) against a BMI benchmark previously proposed (Abbott & Faisal, 2012, JNeuralENg). With the growing understanding of eye-movements, our work shows that perception-action neurotechnology can start to deliver intention-decoding BMIs that rival invasive neural recordings in cost and performance.

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Posters

Medical Imaging

Friday, August 16, 12:20 - 13:30

Room: Stora salen (2nd floor)

Investigation of viewing procedures for interpretation of breast tomosynthesis image volumes: a detection-task study with eye tracking

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Objectives To evaluate the efficiency of different methods of reading breast tomosynthesis (BT) image volumes.

Methods All viewing procedures consisted of free scroll volume browsing and three were combined with initial cine loops at three different frame rates (9, 14 and 25 fps). The presentation modes consisted of vertically and horizontally orientated BT image volumes. Fifty-five normal BT image volumes in mediolateral oblique view were collected. In these, simulated lesions were inserted, creating four unique image sets, one for each viewing procedure. Four observers interpreted the cases in a free-response task. Time efficiency, visual attention and search were investigated using eye tracking.

Results Horizontally orientated BT image volumes were read faster than vertically when using free scroll browsing only and when combined with fast cine loop. Cine loops at slow frame rates were ruled out as inefficient.

Conclusions In general, horizontally oriented BT image volumes were read more efficiently. All viewing procedures except for slow frame rates were promising when assuming equivalent detection performance.

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Recognizing Melanoma - Eye Movement Patterns in Dermoscopy - Differences between novices and those experienced in dermoscopy

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Dermoscopy presents the viewer with a high resolution view of the skin, and is used for diagnosing pigmented skin lesions (PSL). It is hypothesised that important differences occur in the eye-movement behaviour of physicians with different experience levels in dermoscopy.

25 participants (medical students, physicians and dermatologists) were asked to evaluate 36 images representing PSL. All participants evaluated all images using eyetracking before and after an instruction-video. Time to decision, fixation-points, gaze-track-length, time in AOI and fixation-points in AOI were recorded.

The difference of time to decision for the novices was significantly higher after the video. Both groups spent the same amount of the total time in AOI. The novices needed significantly more time after the video than before but the share of time used in AOI was unchanged. In general the novices had significantly more fixation-points in AOI compared to the experts before and after the video. Novices had a longer and more complex gaze track pattern.

We revealed differences in the approach of analysing PSL in an experienced and novice group. Furthermore differences were revealed in the eye-movement pattern after an instruction-video. The results may aid in the improvement of the use of PSL-algorithms among especially novices.

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Memory Indexing - Looking at Nothing for Process Tracing of Diagnostic Reasoning

Georg Jahn & Janina Braatz
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In diagnostic reasoning, knowledge about symptoms and their likely causes is retrieved to generate and update diagnostic hypotheses in memory. By letting participants learn about causes and symptoms in a spatial array, we could apply eye tracking during diagnostic reasoning to trace the activation level of hypotheses across a sequence of symptoms. Gaze allocation on former locations of symptom classes and possible causes reflected the diagnostic value of initial symptoms, a bias towards the focal hypothesis, symptom rehearsal, and hypothesis change. Gaze behavior mapped the reasoning process and was not dominated by auditorily presented symptoms. Thus, memory indexing proved applicable for studying reasoning tasks involving linguistic input. The results extend previous findings on gaze behavior reflecting semantic integration in language processing obtained in the blank screen paradigm to a more complex inductive inference task. Furthermore, we tested whether former locations of cause and symptom information would still influence gaze allocation after a longer delay. Looking at nothing revealing memory activation consistent with process models of diagnostic reasoning was stable even after one week.

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Posters

Smooth pursuit

Friday, August 16, 12:20 - 13:30

Room: Stora salen (2nd floor)

Velocity Perception using interocular velocity differences of smooth pursuit eye movements

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Binocular coordination of eye movement is essential for stereopsis and to prevent double vision. Previous studies show that each eye is controlled independently and eye signals are encoded monocularly (e.g. Zhou & King, 1998; King & Zhou, 2002). In this study, we investigated the perceived velocity, dependent on the integration of monocular smooth pursuit movements of each eye. We measured the perceived velocity of fused moving images using the method of magnitude estimation. Stimuli were circular patterns which moved horizontally and were presented dichoptically to the eyes in a mirror stereoscope. We compared three conditions in which the stimulus for one eye was stationary or moved (0, 1, 2 deg/s) while that for the other eye was moved with interocular velocity differences (1, 2, 4 deg/s). The modulus was a perceived velocity of the stimuli for both eyes when they were moved together (2 deg/s). The results suggest that as interocular velocity differences became larger, the perceived velocity of the target in the monocular pursuit (one eye was stationary) increased more sharply than that in the binocular pursuit. Finally, we discussed how velocity perception during pursuit movement is determined by interocularly integrating the velocity signal of each eye.

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Can subjects use voluntary smooth pursuit to guide hand movement?

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Smooth pursuit eye movements are typically controlled as a feedback system that negates retinal image motion. However, in special circumstances smooth pursuit can exhibit predictive characteristics that allow it to be driven by non-retinal input. In cases where eye movements lead hand movements, gaze trajectories can be characterized by a series of saccades and segments in between saccades. With stationary saccade and hand targets, the inter-saccadic segments are expected to be fixations, i.e., with a distribution of gaze velocities centered around 0 deg/s. Instead, in a video-game task where gaze led two thumb/joystick-controlled cursors upward through 40 degrees of blank screen, this distribution was broad and unimodal, ranging from 0 deg/s to more than 20 deg/s. Furthermore, gaze was ahead (higher on the screen) and its speed was not well correlated with cursor speed, suggesting predictive smooth pursuit. The gaze characteristics in this task will be compared with other eye-hand tasks, where the fingertip moved along a fully-visible path, or the finger intercepted a target moving through a non-stationary background. The results describe interactions between saccadic/fixation and smooth eye movement control systems and may facilitate the development of therapeutic interventions in conditions like oscillopsia.

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Temporal dynamics of directional precision of pursuit and initial saccades

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Primates combine pursuit and saccadic eye movements to track moving objects. For continuous foveation of dynamic objects the oculomotor system depends on precise, rapid speed and direction estimates and appropriate oculomotor responses. We measured in humans temporal dynamics of directional precision of pursuit with step-ramps and initial saccades with ramps. A spot moved horizontally in 7 vertical directions between ± 10 deg. Eye directions of trials were compared to those conducted to horizontal ramps to construct oculometric functions for direction discrimination for each point in time. For pursuit responses it took 250 to 300 ms until directional precision reached thresholds of 2 degs. Directional precision of pursuit trials showed a speed-accuracy trade-off, with larger latencies higher pursuit precision was reached quicker and cancelled out latency disadvantages. Initial saccades to ramps indicated directional precision of 2.5 degs. At saccadic onset directional precision of pursuit was still larger than 7 degs. Higher directional precision of saccades was also present at low contrast and isoluminance. The saccadic system reaches higher precise direction estimates presumably through positional information, not available for the pursuit system. Therefore initial saccades to moving targets can improve directional precision smooth pursuit movements rapidly.

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Characteristics of smooth pursuit on familiar and unfamiliar 2D-trajectories

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Human smooth pursuit is largely supported by predictive mechanisms allowing to compensate for the latency of visual processing. Decreased pursuit latency is the main indicator for prediction. To characterize the differences in the smooth pursuit system in the presence and absence of predictive components in more detail, this study evaluates differences in gain, latency, velocity error, and the strength of the coupling between velocity error and eye acceleration.

Subjects pursued a target which moved on an either familiar or on an unfamiliar trajectory. Subjects familiarized with one of the four randomly generated cyclic 2D-trajectories, by 30 successive pursuit trials on that trajectory (TF). After this training, TF and the three unfamiliar trajectories (TU) were presented in random order.

After desaccading, a constant gain factor was fitted to the slow-phase components of velocity error (eye – target) to explain eye acceleration. This procedure was done for all delays between eye and target between 0 and 400 ms. The latency of the visual response was determined by the delay maximizing the R-square of this simple model. The gain was similar on TF and TU, whereas latency, velocity errors, and R-square were smaller on TF than on TU.

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Pupillary responses to perceived gaze direction and facial attractiveness

Helene Kreysa, Lisa Blatz & Stefan R. Schweinberger
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In interpersonal communication, pupil size has been shown to increase when perceiving eye gaze contact with a conversational partner (Porter, Hood, Troscianko, & Macrae, 2006; Honma, Tanaka, Osada, & Kuriyama, 2012). There is also evidence that the perception of facial attractiveness interacts with the perception of eye contact (Kampe, Frith, Dolan, & Frith, 2001; Ewing, Rhodes, & Pellicano, 2010; Kloth, Altmann, & Schweinberger, 2011). Here we investigated whether perceived eye contact and attractiveness elicit additive or interactive effects on pupil dilation, which is generally assumed to be independent of conscious awareness (Laeng, Sirois, & Gredeback, 2012). Based on previous ratings, we selected a total of 36 attractive and unattractive faces (9 male and 9 female faces of each type) and manipulated their eye regions to achieve an impression of direct or averted gaze. We excluded confounds between facial attractiveness and eye regions by using identical sets of eye regions for both conditions. All faces were presented in pseudo-randomised order on a black background for 3000 ms, with an inter-stimulus interval of 3000 ms. Participants rated the perceived attractiveness of each face by pressing one of four horizontally aligned keys. Pupil dilation was recorded with an iView X Hi-Speed tracker (SMI).

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Microsaccades do not correct for disparity error during smooth pursuit in depth

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In our stereoscopic experiment subjects had to pursue a target moving in depth. The target was static in one eye and was describing a harmonic, unpredictable trajectory in the other. Both displays are perceptually fused giving a vivid depth impression. We employed two oscillation frequencies. We find gaze trajectories for both eyes oscillating in phase with the oscillating fixation point, though much weaker in the eye presented with the static display. Microsaccades occurring simultaneously in both eyes are strongly coupled with respect to their orientations, whereas vergence movements where rare. In addition, microsaccades did not contribute to changes neither in overall disparity nor in disparity error with respect to the task. In contrast microsaccade direction predicted the direction of the upcoming pursuit movement.

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Posters

Real World Eye Tracking

Friday, August 16, 12:20 - 13:30

Room: Stora salen (2nd floor)

Effects of roadside advertisements on visual search during simulated and real driving

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Driving vehicle demands constant information processing and interaction with the complex surrounding. In this interaction safe driving is determined by effective functioning of visual attention. Recent studies showed that visual strategies of drivers depend not only on driving experience but also on presence of distractors, such as roadside advertisements. This work is aimed at presenting two studies illustrating how the presence of billboards affects driver's visual search. First research was conducted with the use of advanced driving simulator while the second one was conducted in real traffic. In both cases SMI EyeTracking Glasses were used. These studies proved that the presence of billboards significantly influence driver's visual strategies. Roadside advertisements attracted numerous fixations, they attracted more attention than road signs. Additionally, studies proved differences in eye movements depending on driver's experience and task difficulty. Experienced drivers fixated their eyes on billboards more often than novice drivers. Finally, both studies indicate problems of using mobile eye tracking device, which may occur while conducting research with the use of driving simulator and on the real road.

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Guidance from working memory can influence real world object search

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Working memory (WM) can exert an early and involuntary influence on visual selection in search for simple artificial targets defined by a combination of colour and orientation [Soto, D., Heinke, D., Humphreys, G. W., & Blanco, M. J. (2005) Journal of Experimental Psychology: Human Perception and Performance, 31, 248]. Here, we demonstrate similar effects even for search complex real world objects. At the beginning of each trial, participants were asked to remember a single object that could either be the search target or a distractor in the subsequent search array. The search target was easily discriminable from distractors on the basis of orientation. Despite this, the object in WM affected the latency of the first saccade during search, the time taken to fixate the target and the direction of the first saccade. This pattern of results suggests that top-down feedback from WM, can modulate oculomotor selection even for complex real world objects.

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Correlating eye movements with indoor visual comfort perception under artificial lighting

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The aim of this study is to characterize human visual comfort in different environments and configurations. The work was mainly developed to highlight LEDs luminaires peculiarities in internal lighting.

A domestic in-lab realistic configuration have been created, in order to assess subjective evaluations of visual comfort in a controllable and reproducible way.

The experiment has been performed during latest month of 2012 with the participation of 50 subjects, divided in three different age groups. Self rated visual fatigue before starting the experiment has been considered, the iris colour reported and personal home lighting habits questioned.

From data analysis, that will be carried out in the next two months, we expect to find a correlation between the light distribution in the test room, the visual human behaviour (through gaze analysis and saliency maps) and the comfort perception assessed by some questionnaires.

Some methodological consideration and hints will be given, considering experimental design and the specific eye tracker used too.

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Looking at the end of a bend

Esko Lehtonen & Otto Lappi
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Two types of fixations have been identified in the visual control of action: guiding fixations and look-ahead fixations. Guiding fixations target objects or locations relevant for the current phase of the task. In look-ahead fixations, gaze is disengaged from the guidance of the current phase, and shifted toward objects or locations relevant for the future phases of the task, before returning back to the guidance of the current phase.

Using eye movement data from three on-road driving studies, I demonstrate that guiding and look-ahead fixations can be identified also in the control of locomotion when steering on curved roads. In open curves, the guiding fixations follow the road ahead with approximately 2 s lead time, while look-ahead fixations target the end of a bend. Both inexperience and additional cognitive load reduce look-ahead fixations, but their effect is moderate. This suggests that look-ahead fixations in curve driving are manifestation of a general well-learned visual strategy used in locomotion.

Relevance of the look-ahead fixations for visual control of locomotion and for two-level steering models is discussed.

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Assessment of emotional impact of lighting using fixation data with iMap

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The emotional effect of different light spectra on real world objects (textile probes, fruits & vegetables) was investigated here. The effects of three LED generated and one conventional light spectra were compared against each other. The main paradigm was a forced choice task for two light boxes were the objects were displayed. The gaze position of the dominant eye was recorded during the main task with 250Hz. A total of 120 subjects participated. Impulse noise was removed by a signal dependent rank ordered mean (SD-ROM) algorithm. Fixations were classified by a Minimum Spanning Tree (MST) algorithm. The fixation maps were analyzed with iMap (Caldara & Miellet, 2011). The iMap results were compared to behavioral decision data. We analyze which illumination source leads to the highest emotional valence in perception of the objects. Therefore Bradley Terry Luce (BTL) scaling was used to construct a scale of the emotional influence of the different light spectra. The magnitude of the emotional influence was compared to results of a sub experiment utilizing the International Affective Picture System (IAPS) scale to determine the emotional impact of different lighting sources. Results of a pilot study indicate there is a clear winning LED spectrum for each category.

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Linking the visual search skills of safe driving to executive functions among young novice drivers

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Young drivers are involved in a disproportionate number of car-accidents. Driving is a complex task that requires higher behavioral control abilities. Higher cognitive control functions, so-called executive functions (e.g., inhibition, working memory), develop until the late twenties. Although lack of driving experience certainly helps to explain high accident incidence, immature executive functioning might further explain it. As a first step, this study aimed to investigate whether executive functions are related to the driving skill of hazard perception as hazard perception failure is a common problem of young novices' driving.

Fifty young novice drivers drove a 16-km simulated ride that contained several road hazards, while their eye movement behavior was registered (FaceLAB 5). More specifically we were interested in fixational and saccadic measures for the different road hazards. In addition driving measures of speed and lateral control were analyzed. Executive functions were assessed with separate computerized tasks: Stop Signal Reaction Time task (SSRT), Attention Network Task (ANT), Useful Field of View (UFOV) and Working Memory tasks (WM tasks).Using regression analyses, the drivers' hazard perception (related eye movement and vehicle control data) behavior were analyzed in function of executive functioning performance scores. The results and implications for future interventions will be discussed.

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